DOCUMENT RESUME

ED 344 192 CS 010 903

AUTHOR Davis, Wesley K.
TITLE Neurolinguistic Annotated Bibliography (Brain Research and Language Function) with Implications for Education.
PUB DATE 85
NOTE 60p.
PUB TYPE Reference Materials - Bibliographies (131)

EDRS PRICE MF01/PC03 Plus Postage.
DESCRIPTORS Annotated Bibliographies; Brain Hemisphere Functions; Higher Education; Language Arts; *Language Processing; *Neurolinguistics
IDENTIFIERS *Brain Research; Educational Issues

ABSTRACT

This bibliography presents annotations of 91 journal articles, books, chapters in books, and conference papers dating from 1967 to 1984 concerning neurolinguistics, language processing, and educational implications of brain research. The annotated bibliography includes eight items on neuroanatomy and language function; 20 items on neurolinguistics in language processing and production; 34 items on hemisphericity and language function; and 29 items on educational implications of brain research related to teaching the language arts in reading, writing, and oral communication. (Nine figures are included.) (RS)

Neurolinguistic Annotated Bibliography
(Brain Research and Language Function)
with Implications for Education

Wesley K. Davis, Ph.D.
Division of Humanities
Dalton College
213 N. College Drive
Dalton, Georgia 30720
(706) 272-4499

TABLE OF CONTENTS

Neuroanatomy and Language Function 1

Appendix (Neuroanatomy) 8-A

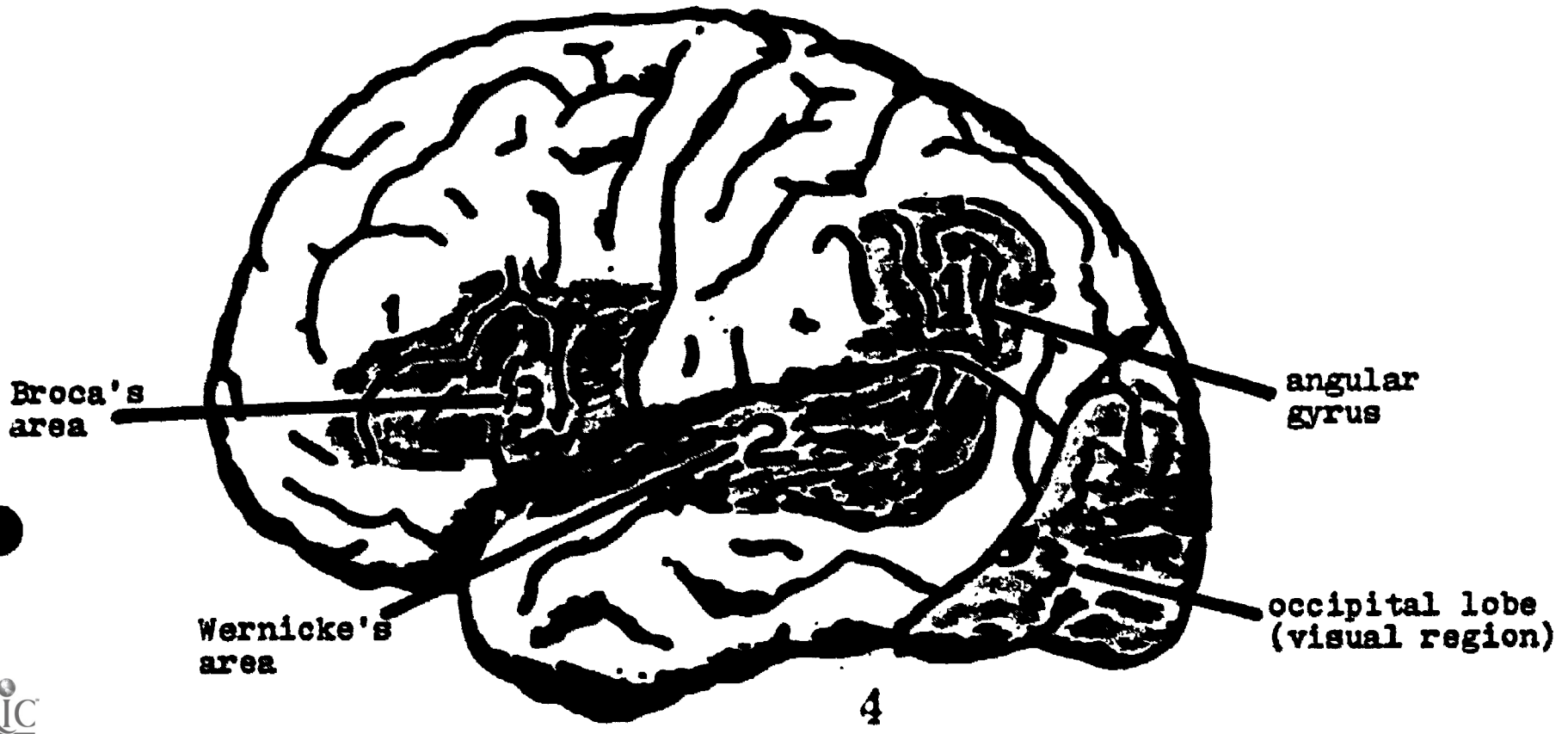
Neurolinguistics in Language Processing and Production (Reading, Writing, Speech, and Perceived Speech) 9

Hemisphericity and Language Function 20

Educational Implications of Brain Research Related to Teaching the Language Arts in Reading, Writing, and Oral Communication 40

Geschwind, N. (1972). Language and the brain. Scientific American, 226(4), 76-83.

Comprehension of written language requires connections from the visual regions to the speech regions. This function is served by the angular gyrus (1), a cortical region just behind Wernicke's area (2), converting visual stimuli into auditory form. During language production, Wernicke's area receives output from the primary auditory area of the cortex. If the word is to be spoken, this pattern is transmitted from Wernicke's area to Broca's area (3), where the articulatory form is aroused. If the spoken word is to be spelled, the auditory pattern is passed to the angular gyrus, where it elicits the visual pattern. When a word is read, the output from the primary visual areas passes to the angular gyrus, which then arouses the corresponding auditory form in Wernicke's area, resulting in comprehension of the written word. In addition, the splenium is the section of the corpus callosum that transfers visual information between the two hemispheres; the splenium allows stimuli from the visual cortex of the right hemisphere to reach the angular gyrus of the left hemisphere, thus converting the visual pattern of a word into the auditory pattern in order for comprehension of the seen word to take place, according to Wernicke's model.*In addition, the visual-verbal associations in reading, writing, and spelling are mediated by the angular gyrus (Gannett & Diller, 1981-- see page 45 for a full reference).



The left temporal region is responsible for linguistic-semantic abilities, short-term auditory memory, and phonetic analysis. For man's brain structure, the location of the angular gyrus is at the juncture of the temporal, parietal, and occipital lobe-association zones, all important in reading. And expressive speech has long been localized in Broca's area, which is connected by association fibers via the arcuate fasciculus to Wernicke's area in the left temporal lobe. Moreover, it is believed that a mechanism exists in the left occipital lobe for processing letter strings as words. On the other hand, it is believed that a similar mechanism exists in the right occipital lobe except that it processes imageable words, such as concrete nouns that can be visualized; most patients having difficulty in accessing the visual-spatial aspects of words might have a dysfunction in the right occipital lobe, where rudimentary visual features of words are processed. A pathway appears to go through the right occipital region, where the imageability of words are processed, and then through Wernicke's area, where words are processed as wholes and meaning is attached in order for rapid whole-word recognition and comprehension to take place. What's more, in the region of the angular gyrus, a mechanism may exist for grapheme-phoneme correspondence; the conceptual pathway follows from the region of the occipital lobes to the angular gyrus, where grapheme-phoneme conversion particularly occurs in reading. Finally, oral reading results from participation of Broca's area. Although brain models appear sequential in processes, in reality there probably exist many feedback loops.

Figure 1

Graphic representation of the cerebral cortex noting major landmarks and lobes

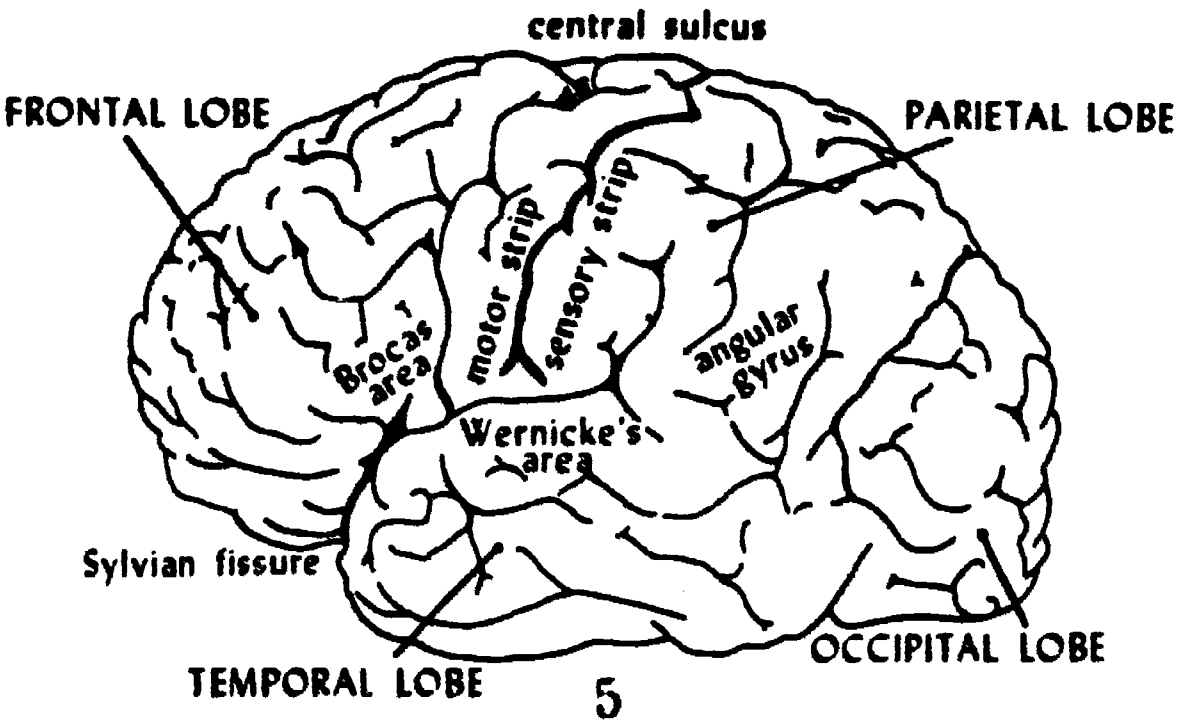


Figure 2

The brain as viewed in horizontal section. The major pathways and cortical regions thought to be involved in reading are depicted. Neurolinguistic processes important in reading are also noted.

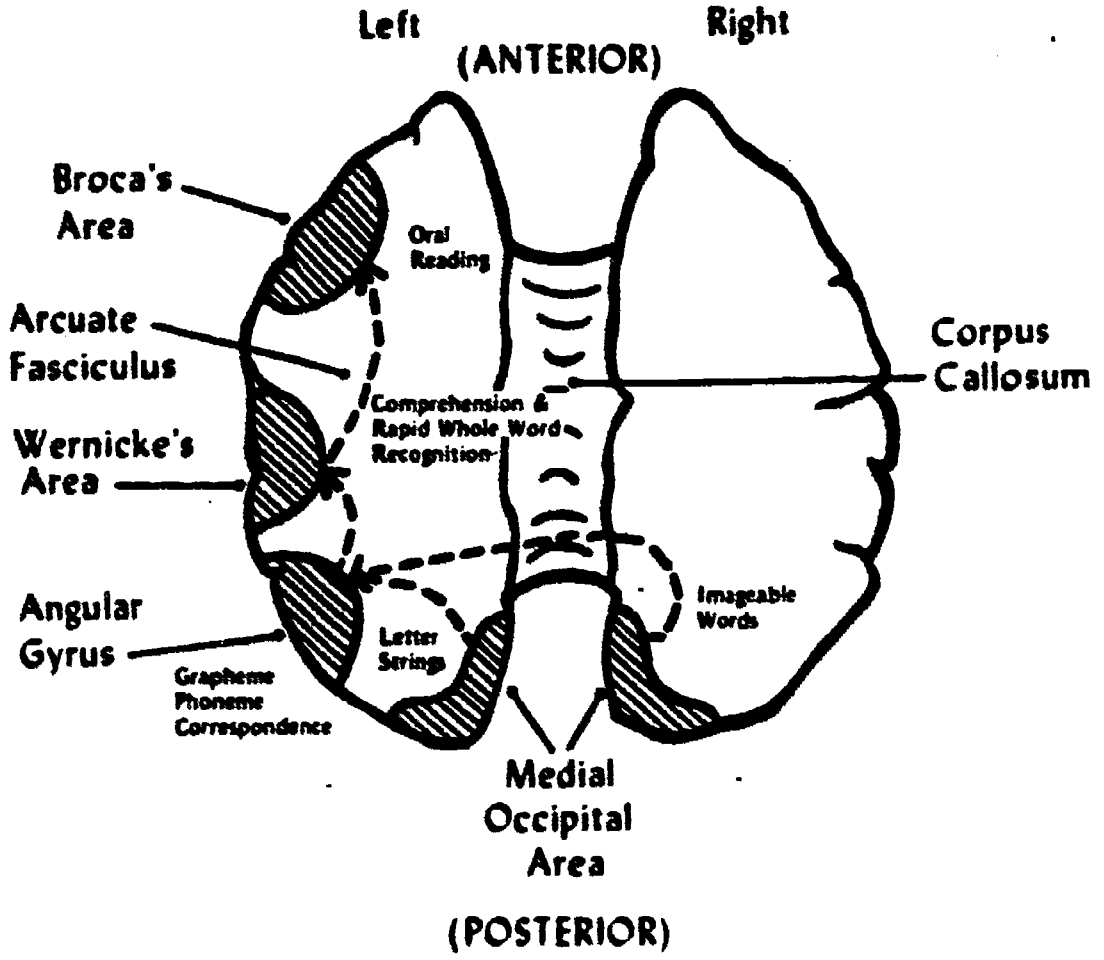
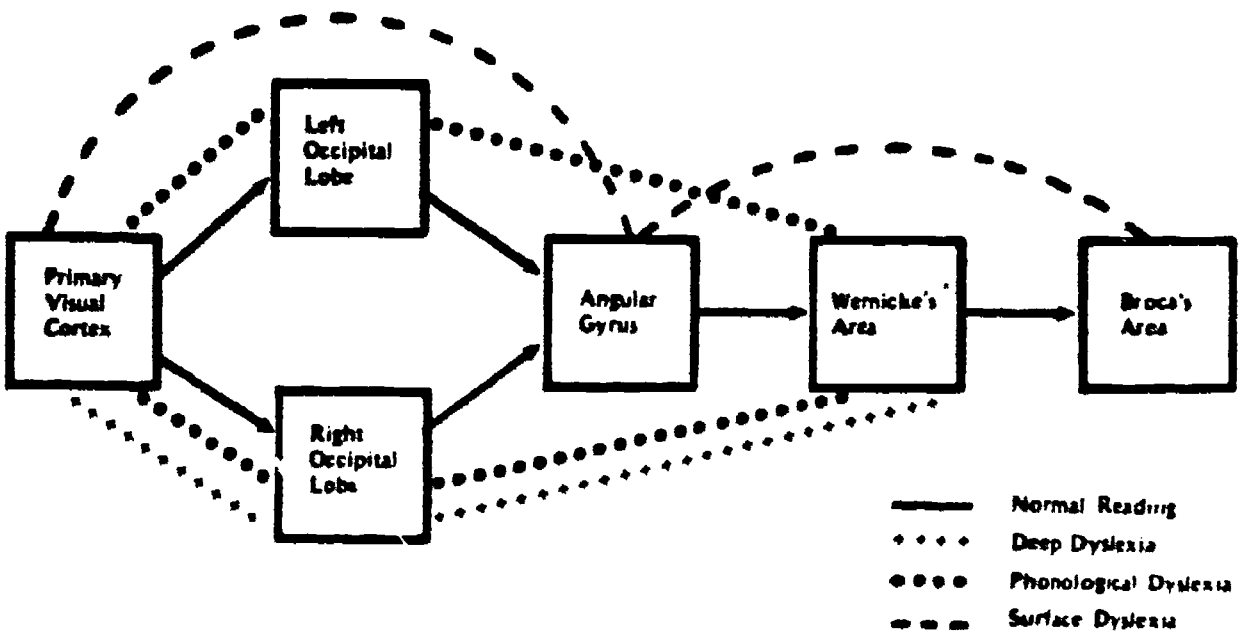


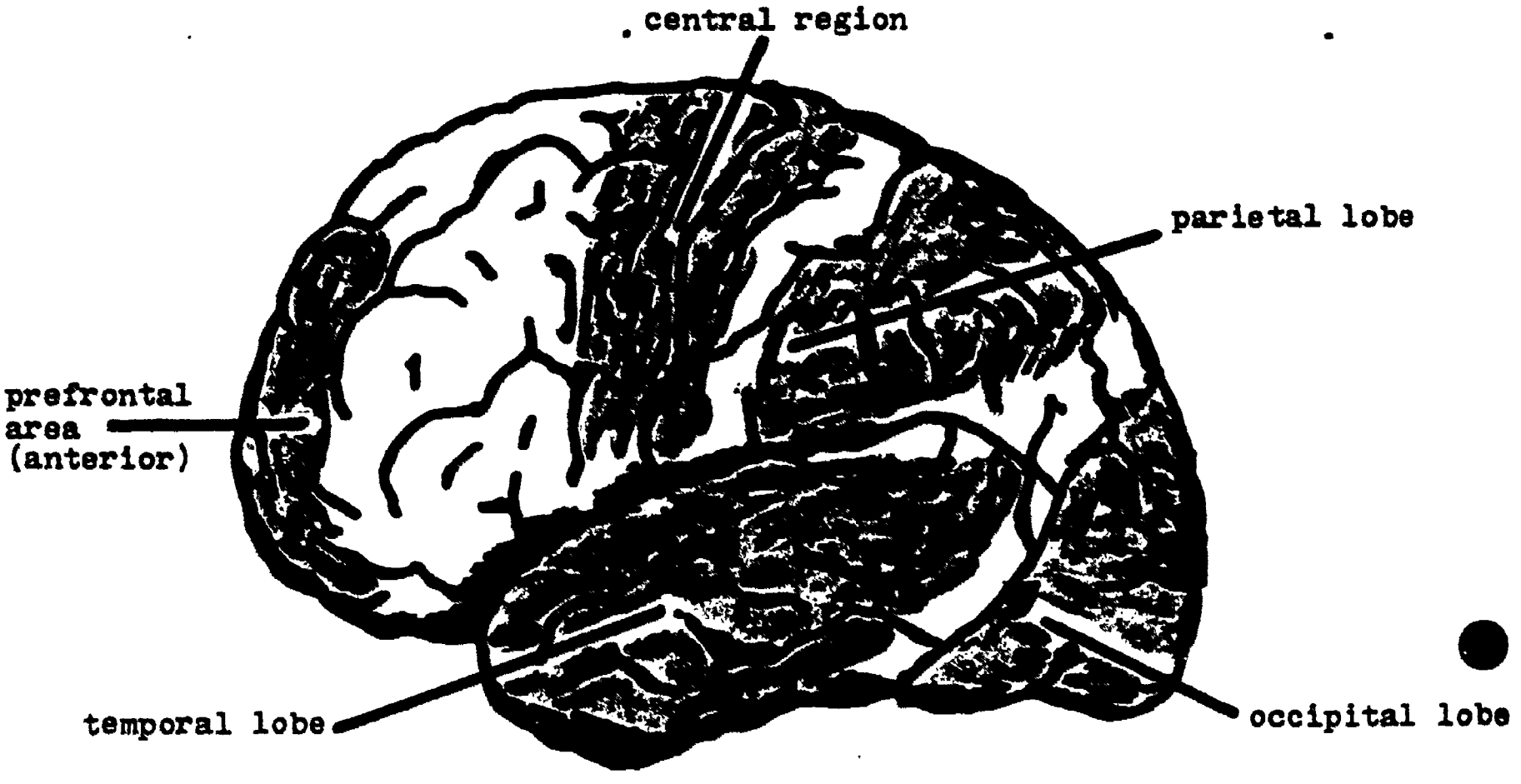
Figure 3

A neurolinguistic model of reading for the surface, phonological, and deep dyslexic (adapted and modified from Sevush, 1983). It should be emphasized that the phonological nonphonological or visual, nonvisual components of these pattern types are only aspects of the pattern which also includes semantic, syntactic, and imageability components. However, the surface dyslexic could be said to access print through phonological or nonvisual modes. The phonological and deep dyslexic may access print through nonphonological or visual modes.



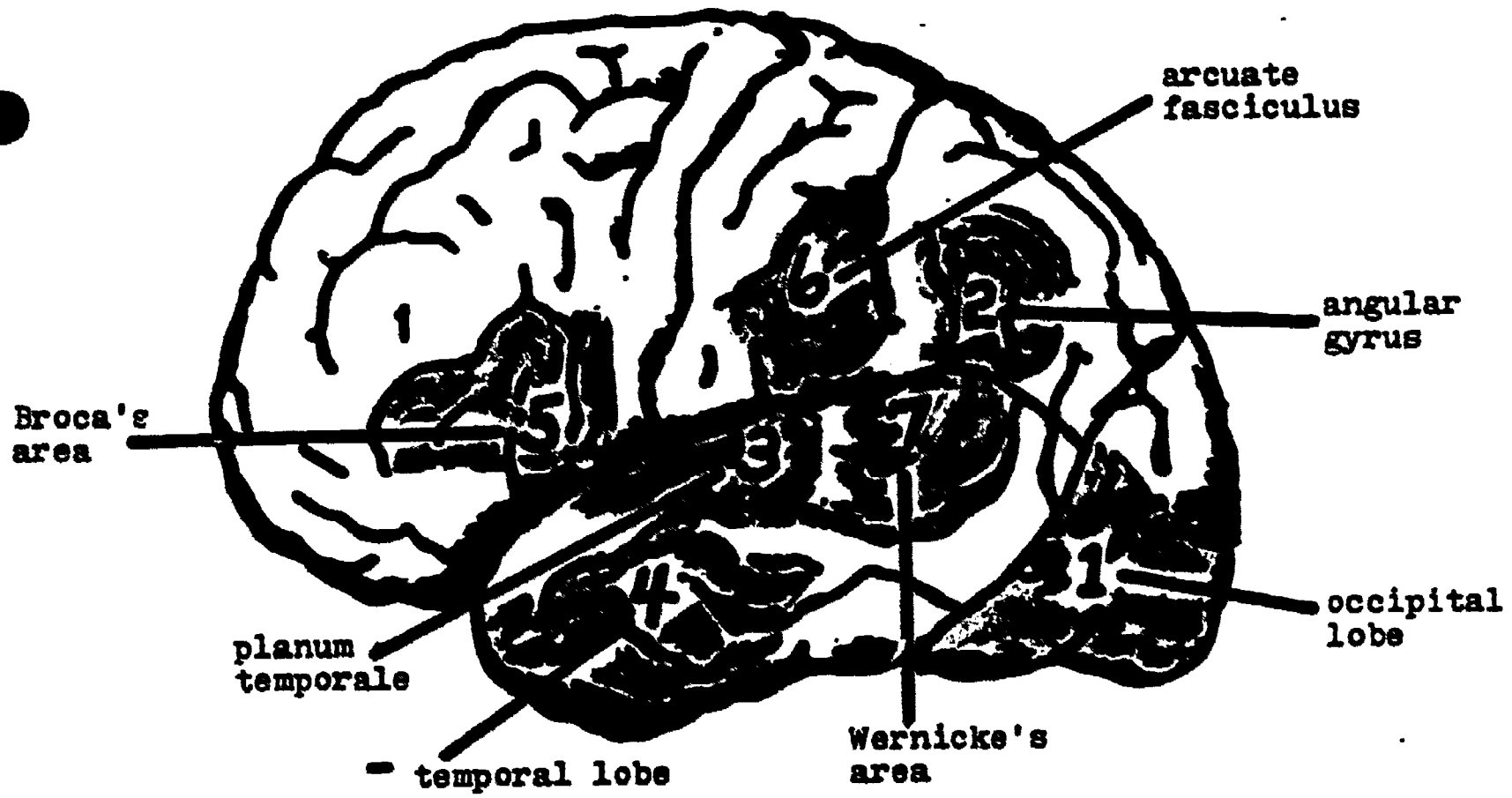
Luria, A.R. (1970). The foundational organization of the brain. Scientific American, 222(3), 66-78.

Luria's brain-process model for writing: Since a word is composed of sounds or phonemes, each coded by a letter or a combination of letters, the recognition of a word may depend on very slight differences between phonemes and acoustic cues, so the speech areas of the brain's left temporal lobe must perform a sharp analysis of phonemes; in the process of word recognition and in the evaluation of speech sounds, articulation of sounds clarifies the word's acoustic form, occurring in the central region of the left hemisphere; the next step to writing is coding the word's sound units (phonemes) into writing units (letters), calling on the cortex's visual zones of the occipital lobes and the spatial zones of the parietal lobes, in order to visualize the structure of a letter, to grasp the spatial relationships among the parts of a letter, and to put the parts together to make a whole word; the mental process of writing also involves sequencing letters (sequential analysis is located in the prefrontal area of the left hemisphere's anterior region. This analysis of the writing process is one of the tracers used in the psychological exploration of the functional organization of the brain.



Luria, A.R. (1980). Higher Cortical Functions in Man. New York: Basic Books.

Luria states that the brain's higher nervous processes are a highly differentiated system whose parts are responsible for different aspects of the unified whole. Higher order cognitive and neurolinguistic processes, such as reading, involve a widely distributed functional system of interacting cortical zones working in concert. Luria's model of reading presupposes that the visual material is registered in the occipital lobe (1), where associations are made between visual stimuli and known letters or words. The information is also shared with input from other sensory modalities in the region of the angular gyrus (2). Coupled with linguistic-semantic comprehension from the region of the planum temporale (3) and the temporal lobe (4), this information is then shared with Broca's area (5) via the arcuate fasciculus (6). Simultaneous and sequential processes are involved at different levels.

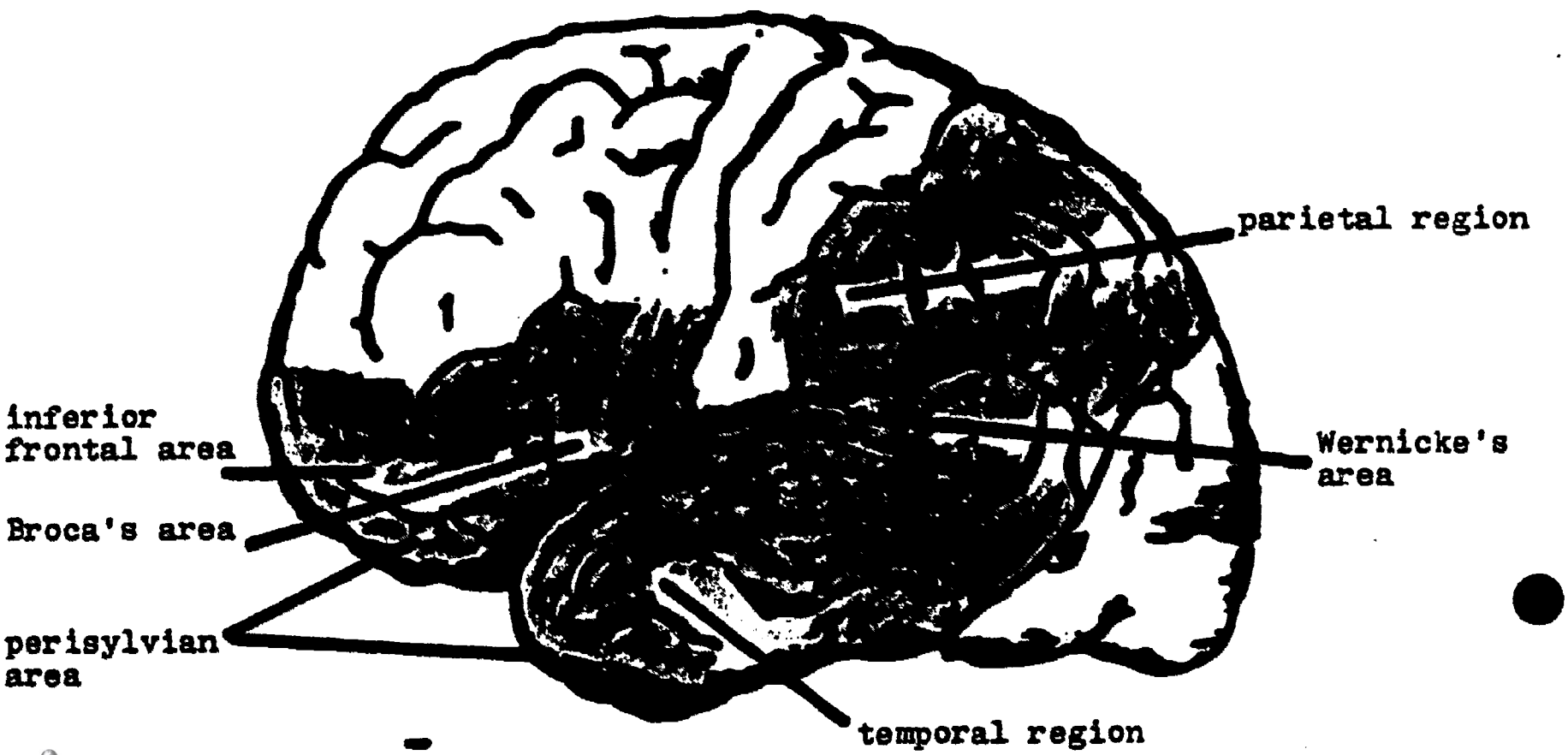


Duffy, F.H., Denckla, M.B., Bartels, P.H., & Sandini, G. (1980). Dyslexia: Regional differences in brain electrical activity by topographical mapping. Annals of Neurology, 7, 412-420.

During reading and listening tasks in EEG studies of dyslexics, it was concluded that Wernicke's area (7) is also involved in the functional systems of reading and speech, in addition to Broca's area, the angular gyrus, and the arcuate fasciculus.

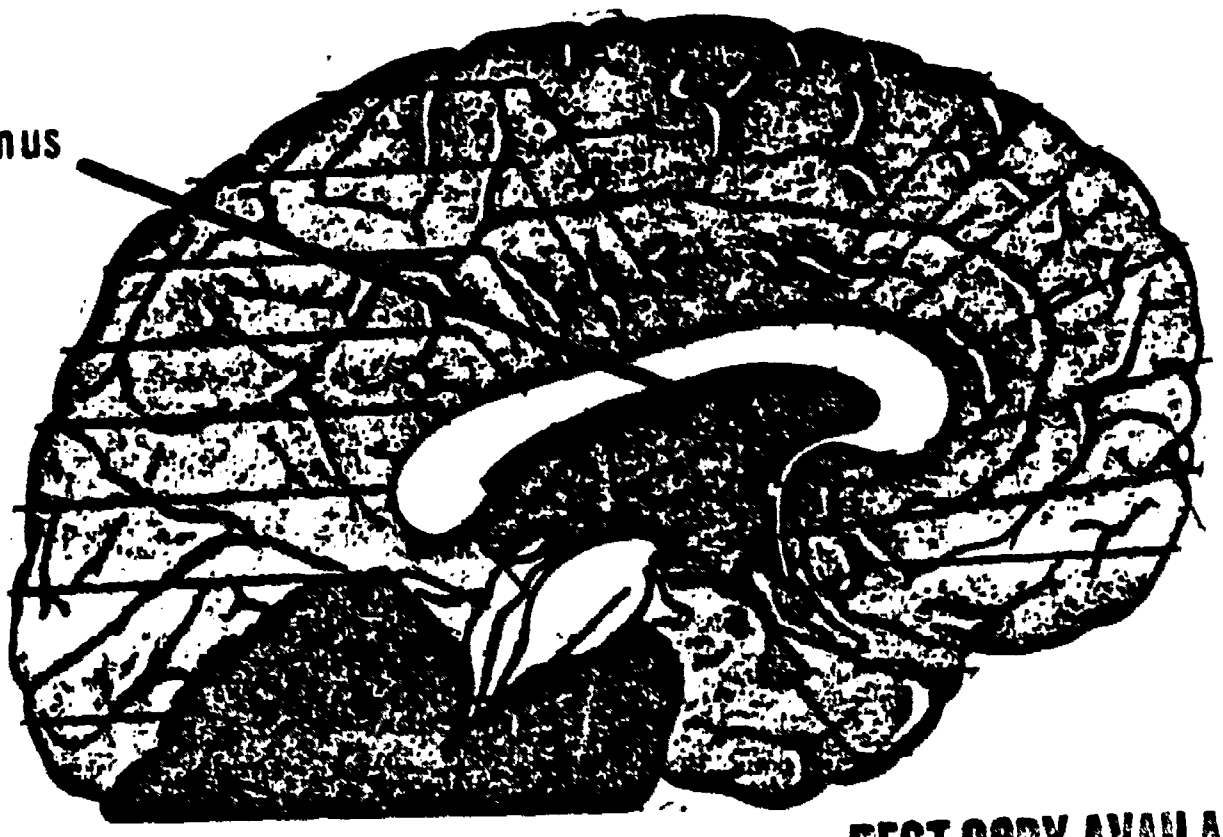
Mateer, C.A. (1983). Motor and perceptual functions of the left hemisphere and their interaction. In S.J. Segalowitz (Ed.), Language Functions and Brain Organization. New York: Academic Press.

It is well recognized that the cerebral hemispheres are organized asymmetrically for functional behavior. The LH in almost all right-handers is specialized for language, the RH for nonverbal functions. Most of the literature regarding the nature and function of the "dominant" LH stresses the representational or sign-referent characteristics of language. Language has traditionally been localized in two regions of the perisylvian cortex of the dominant, usually LH: (1) an inferior frontal subdivision for the production of speech, involving Broca's area, classically thought to be involved in expressive language, which is activated together with the primary auditory areas when a normal subject listens to speech; (2) a parietal-temporal region for understanding speech, in which larger acoustic units (words and phrases) come to be associated with meaning in semantically based and phonologically based Wernicke's area. The LH's perisylvian area appears to be specialized for perception of sequences of auditory stimuli, necessary for phonetic decoding of speech, though not necessarily for larger units of speech comprehension. Development and maintenance of oral communication depend on the perisylvian area of the LH.



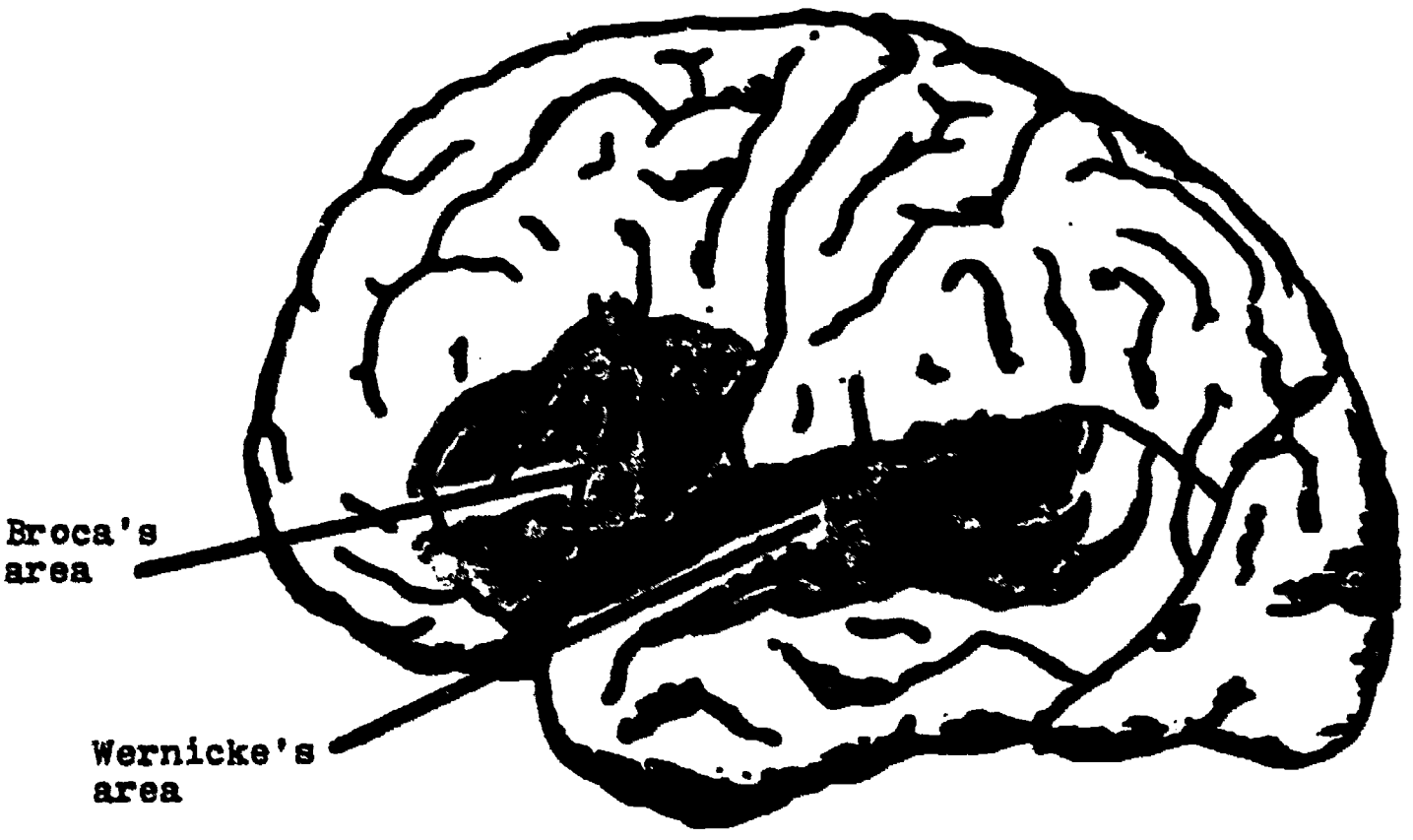
Mateer, C.A., & Ojemann, G.A. (1983). Thalamic mechanisms in language and memory. In S.J. Segalowitz (Ed.), Language Functions and Brain Organization. New York: Academic Press.

There is lateralization of language functions at the level of the thalamus, differing from language functions subserved by any other cortical area. Studies relate the left thalamus to ideational aspects of speech. Different patterns of "naming" are evoked in different portions of the left thalamus, suggesting that subdivisions of it subserve different functions of the language process. The thalamus's pattern of memory has been modeled as an alerting circuit that directs attention to incoming information, while simultaneously blocking retrieval of already internalized material and, thus, controlling access to or from memory. A high level of attention to incoming information increases the likelihood of later retrieval of information. This alerting circuit seems to represent a common thalamic mechanism for both language and memory. The relative activation of this thalamic system in the LH or in the RH may serve to focus attention on verbal or nonverbal features of environmental input. Moreover, this thalamic alerting circuitry may also act as a switching mechanism to activate the appropriate areas involved in language processing of information in the auditory and visual modes. Findings do show that thalamic motor activation is closely related to "higher level" cognitive activation or alerting for language and memory. Finally, stimulation of the dominant thalamus is associated with the evoked alerting effects on verbal and nonverbal "recall" and with the articulatory substrates of speech.



Teyler, T.J. (1977). An introduction to the neurosciences. In M.C. Wittrock (Ed.), The Human Brain. Englewood Cliffs, N.J.: Prentice-Hall.

In the frontal lobe of the left hemisphere are Broca's area and Wernicke's area: Broca's area is primarily concerned with language production because injury to this region results in a person being incapable of producing smooth, well-articulated speech, although content and meaning are normal; Wernicke's area is primarily concerned with the semantic (meaning) aspects of language because injury to this brain region results in well-articulated speech almost totally devoid of content.



*Neurolinguistics in Language Processing and Production (Reading, Writing, Speech, and Perceived Speech)

Anderson, R.M., & Leong, D.C.Q. (1983). The placement of experience in the brain. In S.J. Segalowitz (Ed.), Language Functions and Brain Organization. New York: Academic Press.

Research has shown that the cortical regions do not function in isolation; rather, they may contain many functional potentialities. At both the micro and macro levels, the interconnectivity of brain neurons may function as feedback or feedforward loops, simultaneously affecting multiple neurons of varying brain loci in a complicated response pattern. Also related to the high level of interconnectivity are the possibilities that a specific neuron may subserve more than one function, and that many neurons may share the same function. Moreover, since the visual field is experienced as a unity and not as two halves corresponding to the two hemispheres, then this unity of processes corresponding to visual experience is accomplished by the white matter tracts of the corpus callosum.

Beck, A.R. (1984). The processing of the sounds and meanings of ongoing speech by aphasic subjects. Brain and Language, 22, 320-338.

The study of aphasic miscomprehensions of ongoing speech necessitates a basic understanding of the normal processing of ongoing speech involving the processing of two elements of a message: its sounds (a bottom-up process) and meanings (a top-down process). Thus, the ability of aphasic subjects to process the sounds and meanings of ongoing speech was tested. The subjects heard test sentences containing one member of phonemically similar word pairs in one of three semantic contexts. All subject groups had similar overall patterns of response to the different semantic contexts. In addition, high comprehending aphasic subjects, like control subjects, demonstrated interactive processing of sounds and meaning of speech while low comprehending aphasic subjects did not. The subjects' overall strategy of processing ongoing speech appeared to be based on their accuracy of sound processing on a bottom-up level. (edited from the author's abstract)

Brendt, R.S., Caramazza, A., & Zurif, E. (1983). Language functions: Syntax and semantics. In Segalowitz (Ed.), Language Functions and Brain Organization. New York: Academic Press.

In aphasic patients' ability to process features of sentence form, the claim is that damage to the left anterior cortex selectively limits the ability to implement syntactic features, whatever the linguistic task. Moreover, since "receptive" (comprehension) aphasics clearly show language production problems in that their utterances may be largely uninterpretable, and since "expressive" (naming) aphasics show comprehension problems, the "expressive-receptive" distinction may give rise to the argument that language functions cannot be localized in the brain. The review of research on lexical-semantic disorders allows two conclusions: (1) that the lexical-semantic component can be disrupted independently of phonological and syntactic processing mechanisms; and (2) that the disruption of the lexical-semantic system affects performance in both expressive (naming) and receptive (comprehension) modalities. The argument is that a unitary deficit of the lexical-semantic component of language processing underlies poor performance in all tasks involving the manipulation of "object-category level" information. Finally, Broca's aphasics, Wernicke's aphasics, and Anomic aphasics are also characterized.

Brookshire, R,H., & Nicholas, L.E. (1984). Comprehension of directly and indirectly stated main ideas and details in discourse by brain-damaged and non-brain-damaged listeners. Brain and Language, 21, 21-36.

Aphasic, RH-damaged, and non-brain-damaged subjects heard short narrative paragraphs. Each paragraph contained four main ideas and one or more details related to each main idea. After each paragraph was presented, subjects' comprehension and retention of main ideas and details from the paragraph were tested. The results showed that all groups of subjects remembered main ideas better than they remembered details. Disfluent aphasics and RH-damaged subjects' overall paragraph comprehension scores were not significantly poorer than those of non-brain-damaged subjects. In summary, the

results of this experiment suggest that aphasic and RH-damaged listeners go about making sense of spoken discourse in much the same way that non-brain-damaged listeners do. They give preference to main ideas over details, no matter if the information is given indirectly or directly. The results also suggest that context plays an important role in comprehension of spoken discourse for aphasic subjects, and probably for RH-damaged subjects as well. Consequently, predictions about aphasic listeners' comprehension of discourse in daily-life situations should be based upon their performance on discourse, and not upon their performance on traditional tests of comprehension composed primarily of single-sentence stimuli. (edited from the authors' abstract)

Bruskin, C., & Blank, M. (1984). The effects of word class on children's reading and spelling. Brain and Language, 21, 219-232.

Children's oral language functioning has been shown to be affected by word class (i.e., content vs. noncontent words). The present study reveals comparable effects on children's written language performance. In spelling and reading, third and fifth graders show faster and more accurate responses to nouns and verbs than to noncontent words of matched length and frequency. Further, when the children's performance is examined in relation to the level of reading skill, it is found that the less-skilled readers exhibit a greater content/noncontent differential than do the more skilled readers. The results are discussed with reference to differential access for the two word classes and its implication for both oral and written language functioning. In addition, it has been proposed that access to noncontent words in the LH of normal subjects is through a different mechanism from that which handles content words, whereas in the RH the same retrieval mechanism serves to access both word types. Even if differential access exists, it is not known at this time whether the basis for the differentiation is innate and/or dependent upon experiential factors, such as the different intonation patterns of content and noncontent words in spoken language, or the difference in grammatical roles. (edited from the authors' abstract)

Caplan, D. (1981). On the cerebral localization of linguistic functions: Logical and empirical issues surrounding deficit analysis and functional localization. Brain and Language, 14, 120-137.

It is argued that the view of functional localization holding that aspects of linguistic knowledge or psychological processes localized in areas of the brain in gross neuroanatomical terms is an inadequate concept for capturing brain-language relations. Analysis of pathological performances in terms of models of language is not acceptable as models for normal users because they often appear to presuppose some ideal model of performance and postulate a deficit in it. Brain structures are properties of cells, synapes, and circuits, all of which are the neural elements involved in the representation and processing of the structures of language. Work done on linguistic deficits in abnormal populations makes no contact with what linguists consider to be defensible theories of language structure. (edited from the author's abstract)

Caramazza, A., Brendt, R.S., & Brownell, H.H. (1982). The semantic deficit hypothesis of the naming defect: Perceptual parsing and object classification by aphasic patients. Brain and Language, 15, 161-189.

Proposed is a description of the naming process that attempts to describe the access mechanisms to the name of an object. The focus is on the interaction between the system responsible for perceptual analysis of an object and the object's assignment to a semantic category. The major stages of the processing in this description include the following: (1) a set of perceptual analyses of the object; (2) modality-specific analyses producing a semantically constrained parsing of the perceptual input; (3) the application of a modality-independent classification algorithm to determine the category membership of the object and to allow mapping onto a specific lexical form; and (4) the execution of the phonological information specified for the selected lexical form. In word-object matching tasks (lexical comprehension), a reverse sequence of processes is assumed to take place, with the lexical access mechanisms presumably requiring modality-specific perceptual analyses for graphic and auditory inputs.

Freedman-Stern, R., Ulatowska, H., Baker, T., & DeLacoste, C. (1984). Disruption of written language in aphasia: A case study. Brain and Language, 22, 181-205.

In the past several years linguistic studies have begun to emphasize larger and more natural units of language in terms of texts or discourses. Theoretical text linguistics has illuminated the structure of texts and the psychological processes involved in text comprehension and recall. This study documents the performance of a Wernicke aphasic on the production of written discourse. The discourse data consisted of spontaneously produced texts of three different types: narrative discourse, personal and formal letters, and expository discourse. A detailed description of the language of this aphasic at a sentence and discourse level revealed preservation of discourse structure through proper uses of cohesive devices despite severe disruption of linguistic structure at the sentence level. (edited from the authors' abstract)

Gardner, H. (1974). The Shattered Mind. New York: Vintage Books.

The study of such brain-damaged patients as aphasics has illuminated issues in human language and has charted pathways in the study of higher cortical functions. Aphasia raises questions on whether we do think in words primarily, in sentence-length units, in images, or even imageless entities, or whether words refer to specific objects, classes of objects, or concepts out of which thoughts are composed. In the relationship between language and thought, there is the question of whether a person unable to communicate via language can still retain his/her capacity to think. In addition, according to classical aphasiological theories, Broca's area is responsible for the conversion of ideas, perceptions, and intended messages into smoothly articulated patterns of speech, structured by the appropriate syntactic forms. And Wernicke's area relates incoming sounds to representations (or meanings), which allow the understanding of discourse: selecting and arranging meaningful units for conversion into comprehensive and coherent speech, essential for understanding and emitting language. According to this model, reading and writing depend on a preserved ability to extract meanings from linguistic materials and to encode ideas

into meaningful units. Moreover, overall linguistic skill represents the sum of a large number of relatively separable functions and reveals the subtle interrelations of these functions. Brain regions subserve such functions as comprehension (auditory-verbal images), reading (visual word images), writing (kinesthetic or tactile word images), and repetition (connecting comprehension with speech areas). Higher-level aspects of language--such as the ability to formulate and utter a complex proposition or to read and write a lengthy text--are more extensively organized, implicating larger brain areas. For instance, such a supremely complex and multifaceted activity as writing requires intactness of a whole range of perceptual, motor, linguistic, and cognitive systems--even as the weakest link breaks the chain, a significant difficulty in any of these cortical functions will undermine the person's ability to express him/herself in written language. As for reading, such disorders as alexia and dyslexia not only reveal insights about the relationship of reading to visual perception, linguistic capacity, and overall "symbolic fluency," but also provide vital pedagogical clues about how the normal person learns to read, perhaps altering the approach to language education and rehabilitatio

Garnsey, S.M., & Dell, G.S. (1984). Some neurolinguistic implications of prearticulatory editing in production. Brain and Language, 23, 64-73.

This paper argues that a complete model of language production must include a prearticulatory editing component. The function of this component is to monitor planned speech for deviations from the speaker's intention and repair any deviations that are found. It is claimed that adding such an editing component onto a production model fundamentally changes any account of aphasic symptoms using that model. It is concluded that the relationship between psycholinguistic models and neurolinguistic data is not straightforward. If brain damage leads to a greater reliance on an "editorial subsystem," which is, itself, a complex system that accesses many types of linguistic knowledge, it is going to be hard to tell what is damaged in the brain. Consequently, researchers will have to develop an understanding of prearticulatory editing in both normal and aphasic language production. (edited from the authors' abstract)

Grossi, D., Fragassi, N.A., Orsini, A., De Falco, F.A., & Sepe, O. (1984). Residual reading capability in a patient with alexia without agraphia. Brain and Language, 23, 337-348.

A case of pure alexia due to a lesion of the occipital temporal region is described. The alexic subject could match written words but could not read them. Immediate memory span for graphemes was defective. The reading defect probably depends on the subject's inability to modify the written word "globally"; the phonological process was intact, but the memory disturbance impeded reading. The dissociation is explained by the preservation of word forms, which are linked to the semantic stage. Nonwritten stimuli trigger a "meaning" which evokes the word form, and so the written word is recognized even though it cannot be read. (edited from the authors' abstract).

Kaczmarek, B.L.J. (1984). Neurolinguistic analysis of verbal utterances in patients with focal lesions of frontal lobes. Brain and Language, 21, 52-58.

Verbal utterances of 105 patients were analyzed. Six groups of subjects were examined including patients with left frontal lesions, right frontal lobe lesions, posterior aphasics, posterior brain-damaged patients without aphasia, and a matched control group. Results showed that the left frontal lobe is involved in the organization of linguistic information: this frontal lobe's dorsolateral part seems to be concerned with forming the sequential pattern of an utterance, and the orbital part with the directed development of a narrative. It is conceivable that the right frontal lobe is important for the global, nonlinguistic organization of information to be uttered. (edited from the author's abstract)

Lenneberg, E.H. (1967). Neurological aspects of speech and language. In Biological Foundations of Language. New York: Wiley.

The neurological processes underlying language are not confined to cortical areas. Many parts of the brain take part in the elaboration of speech and language, and interference may be produced not only by cortical but also subcortical lesions. It

appears reasonable to assume that complex, species-specific behavior patterns, such as language, result partly through subcortical, highly centralized integrating mechanisms and partly through the interaction of functions on most cortical levels. In addition, neural messages are relevant to speech and language as "time-coded." Cortical lesions primarily interfere with temporal integration dealing with words and grammatical categories, whereas deeper lesions (subcortical) disrupt the necessary convergence of various afferent signals and the intimate coordination and integration of efferent impulses, thus producing disorders in language production. It is not so much one or the other specific aspects of the brain that must be held responsible for the capacity of language function, but the way the many parts of the brain interact. Thus, it is the mode of function rather than the specific brain structures that must be regared as the proper neurological correlate of language.

Lenneberg, E.H. (1973). The neurology of language. Daedalus, 102(3), 115-133.

In language function, there are difficulties in postulating brain centers exclusively in charge of specific types of behavior, operating independently as suborgans (i.e., Broca's area being responsible for speaking and Wernicke's area for perceived speech). All areas of nerve tissue are forever active, and the anatomical connectivity of the cortex and the brain as a whole is such that a change in activity in one part of the brain is likely to influence activity in all of those parts of the brain to which it is connected. At any moment, all specialized activities in different parts of the nervous system can be viewed as a single configuration, and the activity patterns of the brain can be seen as a series of moment-to-moment transitions from configuration to configuration.

Lovett, M.W. (1984). A developmental perspective on reading dysfunction: Accuracy and rate criteria in the subtyping of dylexic children. Brain and Language, 22, 67-91.

Children referred with specific reading dysfunction were subtyped as accuracy disabled or rate disabled according to criteria developed

from an information processing model of reading skill. Multiple measures of oral and written language development were compared for two subtypes samples matched on age, sex, and I.Q., the two samples being comparable in reading fluency, reading comprehension, word knowledge, and word retrieval functions. Accuracy disabled readers demonstrated inferior decoding and spelling skills, proving to be deficient in their understanding of oral language structure and in their ability to associate unfamiliar pseudo-words and novel symbols in a task designed to stimulate some of the learning involved in initial reading acquisition. It was suggested that these disabled readers may be best described with respect to their relative standing along a theoretical continuum of normal reading development. (edited from the author's abstract)

Obler, L.K. (1983). Language and brain dysfunction in dementia. In S.J. Segalowitz (Ed.), Language Functions and Brain Organization. New York: Academic Press.

As neurolinguistic strategies become more sophisticated, it becomes clear that the dementias will provide a rich realm for expanding the knowledge of brain systems or mechanisms underlying language processes. For example, it is generally held that phonological and syntactic systems are spared in dementia, but semantic and pragmatic systems show deficits. To the extent that semantic and pragmatic aspects of communication are deemed linguisitic, then there is language loss, along with cognitive skills, in dementia. What's more, lexical items which reflect semantic specificity may be difficult to assess and may be misused in dementia.

Ostergaard, A.L., & Meudell, P.R. (1984). Immediate memory span, recognition memory for subspan series of words, and serial position effects in recognition memory for supraspan series of verbal and nonverbal items in Broca's and Wernicke's aphasia. Brain and Language, 22, 1-13.

Four Broca's aphasics, four Wernicke's aphasics, and four matched control subjects were investigated on three verbal and one visual short-term memory tasks. Experiment 1 considered memory span and subspan recognition memory for verbal items, and Experiment 2 assessed serial position effects in supraspan verbal

recognition memory. The Broca's aphasics demonstrated verbal memory deficits, which could not be attributed to linguistic disturbances, while the verbal memory deficiencies seen with the Wernicke's aphasics could be regarded as secondary to linguistic defects. In Experiment 3, where visual recognition memory was investigated, only the Broca's aphasics showed deficient performance. In addition, the Wernicke's aphasics' verbal retention deficits are likely to result from inaccurate or inefficient analyses of verbal input. The memory deficits of Broca's aphasics could be the result of either a general inability to appreciate structure inherent in any material or a failure of verbal rehearsal. A failure to perceive organization may result in poor memory performance with words or faces and could be related to these patients' syntactic deficits. (edited from the authors' abstract)

Shankweiler, D., Smith, S.T., & Mann, V.A. (1984). Repetition and comprehension of spoken sentences by reading-disabled children. Brain and Language, 23, 241-257.

The language problems of reading-disabled elementary school children are not confined to written language alone. These children often exhibit problems of ordered recall of verbal materials that are equally severe whether the materials are presented in printed or in spoken form. Sentences that pose problems of pronoun reference might be expected to place a special burden on short-term memory because close grammatical relationships obtained between words are distant from one another. With this logic in mind, third-grade children with specific reading disabilities and classmates matched for age and I.Q. were tested on five sentence types, each posing a problem in assigning pronoun reference. On one occasion the children were tested for comprehension of the sentences by a forced-choice picture verification task, and on a later occasion they received the same sentences as a repetition task. Results showed that good readers and poor readers differed significantly in immediate recall of the sentences, but not in comprehension of them as assessed by the picture choice. It was suggested that the pictures provided cues which lightened the memory load, a possibility

that could explain why the poor readers were not demonstrably inferior in comprehension of the sentences even though they made significantly more errors than the good readers in recalling them. (edited from the authors' abstract)

Weigl, E. (1975). On written language: Its acquisition and its alexic-agraphic disturbances. In E.H. Lenneberg & E. Lenneberg (Eds.), Foundations of Language Development: A Multidisciplinary Approach (Vol. 2). New York: Academic Press.

The point of view expressed by Vygotsky and his students, such as Luria, maintains that the development of language is the result of the integration of functional cerebral systems. According to this view, the specific and differentiated cortical zones begin to interact and form cerebral systems in language during the course of the process based on the child's communication with his/her environment, facilitated by the interaction of sensory and motor functions. Moreover, in oral and written language performances, cognitive processes come together, such as in acoustic and optic perception, language comprehension, memory, inner speech, and motor processes for speech production. The free flow of writing processes requires the programming of a clearly particular graphic picture and the evocation of a correlated pattern that will control the movements of writing.

Wegner, M., Brookshire, R.H., & Nicholas, L.E. (1984). Comprehension of main ideas and details in coherent and noncoherent discourse by aphasic and nonaphasic listeners. Brain and Language, 21, 37-51.

Aphasic and nonaphasic listeners' comprehension of main ideas and details within coherent and noncoherent narrative discourse was examined. Coherent paragraphs contained one topic to which all sentences in the paragraph related. Noncoherent paragraphs contained a change in topic with every third and fourth sentence. Each paragraph contained four main ideas and one or more details relating to each main idea. The listeners' responses to yes/no questions about each paragraph yielded the following results: (1) nonaphasics comprehended the paragraphs better than the aphasics; (2) both aphasics and nonaphasics comprehended main ideas better than they comprehended details; (3) coherence did not

affect comprehension of main ideas for either group; (4) coherence did not affect comprehension of details by nonaphasic subjects; and (5) coherence affected comprehension of details by aphasic subjects, and their comprehension of details in coherent paragraphs was worse than their comprehension of details in noncoherent paragraphs. In addition, the fact that aphasic listeners are sensitive to the salience of information presented in discourse suggests that they may employ the same strategy that nonaphasic listeners do when listening to discourse, at least with regard to main ideas; that is, aphasics seem to be searching for, identifying, and then remembering main ideas to keep the text globally coherent, just as nonaphasics do. What's more, one possible explanation for the aphasics' better performance on details in noncoherent discourse than on details in coherent discourse relates to semantic anomalies which may accompany aphasia, suggesting that the aphasic person may have difficulty keeping semantically related ideas separate. Finally, the aphasic listener is more likely to encounter discourse than single sentences in his/her daily communicative interactions. Consequently, in order to predict aphasics' comprehension in those interactions, a test of comprehension of spoken discourse seems desirable. (edited from the authors' abstract)

*Hemispheric ity and Language Function

Andy, O.J., & Bhatnagar, S.C. (1984). Right-hemispheric language evidence from cortical stimulation. Brain and Language, 23, 159-166.

While LH dominance for language in most right-handers is unquestionable, clinical observations suggest that the non-dominant RH has a considerable capacity for language. Under certain neuroanatomical conditions, the RH capacity becomes functional and, thus, measurable. This study focuses on evoked language responses during electrical stimulation of the RH in three LH-dominant patients undergoing temporal lobe resections for medically intractable seizures. This study supports the thesis that the nondominant RH normally possesses latent language functions, further supported by observations of split-brain subjects whose RH has a sizable language capacity. (from the authors' abstract)

Bakan, P. (1969). Hypnotizability, laterality of eye movements, and functional brain asymmetry. Perceptual and Motor Skills, 28, 927-932.

It is suggested that the direction of eye movements is related to hemisphericity: left-eye movements relate to RH thought, and right-eye movements relate to LH thought. Left-lookers report more vivid imagery, related to RH specialization for visual-spatial functions, whereas right-lookers tend to be better at LH skills dealing with science and quantitative areas.

Beaumont, J.G. (1983). Introduction to Neuropsychology. New York: Guilford Press.

Just how the brain deals with intelligent and complex human functions is an important subject of investigation, for psychology without any reference to brain physiology can hardly be complete. What's more, regions of the brain are not like "bolt-on parts." The entire brain, and not just the cerebral cortex, must be seen as a whole, acting within the framework of a single comprehensive system of behavioral control. The language system involves sites spread across a large part of the cortex; the brain's posterior systems are for language reception, and the anterior systems are for language production. Cortical areas serving language are lateralized in the LH of almost all right-handers and the majority of left-handers, though left-handers have a less clear lateralization of speech (typically a bilateral representation, with both cerebral hemispheres contributing to the processing of language). There has been a gradual and continuing revision of the assumption that language functions were completely lateralized, for the RH is credited with increasingly sophisticated linguistic abilities, possessing a significant degree of linguistic skill. In fact, various studies have shown that the RH can understand abstract words and a variety of syntactic structures including verbs, sentence transformations, and semantically abstract references, with competence in semantic matching.

Boles, D.B. (1984). Sex in lateralized tachistoscopic word recognition. Brain and Language, 23, 307-317.

Although a generalized sex difference in hemispheric lateralization appears to be established, especially with evidence indicating that males show greater lateralization of function than females, a review of the literature pertaining to lexical tachistoscopic tasks suggests a dissociation by method: females show reduced visual field asymmetries relative to males in lexical decision and naming, but not in word recognition. Here 14 recognition experiments from the author's laboratory are subjected to meta-analysis, and the literature review is confirmed. There is no sex difference in visual field asymmetry for the task, although an overall field difference is found. Possible reasons for the discrepancy with lexical decision and naming findings are discussed. One possibility is that stress on reaction time in those tasks produces a complex interaction between sex, activation/arousal, and hemispheric differences. (edited from the author's abstract)

Broadbent, D.E. (1974). Division of function and integration of behavior. In F.O. Schmit & F.G. Warden (Eds.), The Neurosciences: Third Study Program. Cambridge: MIT Press.

From experimental evidence for the integrative functions in normal human behavior, the two hemispheres must be seen as performing different parts of an integrated performance rather than performing completely separate and parallel functions.

Brownell, H.H., Potter, H.H., Michelow, D., & Gardner, H. (1984). Sensitivity to lexical denotation and connotation in brain-damaged patients: A double dissociation? Brain and Language, 22, 253-265.

Sets of words can be grouped in terms of their denotation or in terms of their connotation. To assess whether these two facets of mearing are disscociable, unilaterally LH and RH-damaged patients were presented with word triads and asked to group together the two words closest in meaning. RH-damaged patients showed a preserved sensitivity to denotation, and a selective insensitivity to connotative facets of meanings. In contrast, the

LH-damaged patients exhibited a preserved sensitivity to connotation as well as a selective insensitivity to denotative aspects of meanings. Inasmuch as normal control subjects displayed a flexible sensitivity to both denotative and connotative aspects of meanings, the results suggest that unilateral brain-damaged patients, in the normal course of encountering written and spoken language, focus on one aspect of word meaning more than the other, and this preference may shape the way and the degree to which they appreciate the intended meanings of linguistic communications. (edited from the authors' abstract)

Bryden, M.P., Hecaen, H., & De Agostini, M. (1983). Patterns of cerebral organization. Brain and Language, 20, 249-262.

In an analysis of aphasia and spatial disorder in 270 patients with unilateral brain damage, the data have been used to estimate the incidence of RH, LH, and bilateral hemispheric representation of language and spatial functions. For right-handers the results suggest that women are more likely than men to show RH language and LH visuo-spatial functions. In left-handers cerebral organization seems to be more affected by the familial history of sinistrality than by sex, with bilateral representation of language and spatial ability both more common in those with a familial history of left-handedness. These findings suggest that both clinical and experimental investigators should pay more attention to the relations between aphasia and visuospatial or other nonverbal functions. What's more,it is inappropriate to assume that one hemisphere is specialized for nonlinguistic functions simply because the other is involved in linguistic processes.

Caramazza, A., Gordon, J., Zurif, E.B., & Deluca, D. (1976). Right-hemisphere damage and verbal problem solving behavior. Brain and Language, 3, 41-46.

It is suggested that the RH assumes the role of processing high-level conceptual or ideational materials, shown by RH-damaged patients in dealing with abstract sentences, logical reasoning, and a coherent stream of thought, in RH linguistic processing.

Foldi, N.S., Cicone, M., & Gardner, H. (1983). Pragmatic aspects of communication in brain-damaged patients. In S.J. Segalowitz (Ed.), Language Functions and Brain Organization. New York: Academic Press.

In a study on the pragmatic aspects of communication, the findings indicated that, while RH-damaged patients were able to recall important facts, they had difficulty apprehending the overall structure of a narrative. Patients were asked to sequence randomly presented sentences in order to produce a coherent, logically formed paragraph. Supported was the hypothesis predicting that holistic processing would be impaired in RH-damaged patients who, despite their intact language abilities, failed to organize the linguistic material to produce the appropriate sequence for the paragraph. The apparent inability to comprehend the "whole situation at hand," and to make appropriate inferences on that basis, may occur in real-life contexts as well as in narrative ones, possibly accounting for some of the social inappropriateness observed in RH-damaged patients, who can rarely be faulted on literal comprehension but who often show an inability to go beyond the literal: they take figures of speech at face value, are unable to appreciate or choose the punch lines of jokes, and have difficulty sorting out essential from adventitious information in extended texts. Accordingly, the RH brain damage has interfered with their ability to decode the extensive and subtle forms of linguistic information and to integrate such information with the situations for which they are suitable. In addition, the undamaged LH is crucial for literal language--phonology, syntax, and low-level semantics--and it seems to control the details of other symbolic modes of communication such as gesture, thereby suggesting the LH's role as a central organizer of communication. However, RH-damaged patients are apparently not successful in processing more complex aspects of language, especially those involved in nonliteral meanings, in more extensive texts of narratives, or in the subtler meanings conveyed by paralinguistic cues, such as intonation and emotional content as well as metaphor, all of which possess meanings extending beyond the literal in complex linguistic entities.

Gardner, H. (1978). What we know (and don't know) about the halves of the brain. Harvard Magazine, 80, 24-27.

This discussion of the LH and the RH points out that the precise nature of specialization or brain "dominance" is disputed because many left-handers and right-handers alike have significant capabilities in the RH. Moreover, there is little scientific evidence that artistry, logical capacity, intuition, and consciousness are located in either half of the brain, despite the claims about the RH and the LH. What's more, an intact LH doesn't ensure adequate comprehension of all linguistic messages, and an intact RH doesn't guarantee adequate aesthetic sensitivity. From the author's research, one plausible explanation is that the LH handles "familiar" information, while the RH deals with "unfamiliar" stimuli.

Gazzaniga, M.S., Smylie, C.S., Baynes, K., Hirst, W., McCleary, C. (1984). Profiles of right-hemisphere language and speech following brain bisection. Brain and Language, 22, 206-220.

A variety of language tasks were administered to two patients who had undergone staged callosal surgery in an effort to control intractable epilepsy. RH lexical capacity varied, and preliminary results suggest that the patient displaying greater semantic power also possesses some syntactic competence. This same patient was also capable of expressive language from the RH. This rare capacity allowed for fresh observations on the dynamic interactions of conscious control that occur in this kind of patient. Moreover, the foregoing experiments demonstrate that both the LH and the RH have a rich lexicon. These findings from the study of this patient also suggest that the RH is capable of a dimension of language not commonly encountered. The present work further suggests that in cases of rich RH language, not only is the lexicon fairly developed, but some control of syntax can surface as well. (edited from the authors' abstract)

Goldberg, E., & Costa, L.D. (1981). Hemisphere differences in the acquisition and use of descriptive systems. Brain and Language, 14, 144-173.

Differences in the neuroanatomical organization of the cerebral hemispheres may account for two functional distinctions in processing: (1) the RH displays a predominantly interregional pattern of brain connectivity and has a greater ability to perform intermodal integration of the hemispheres and to process novel stimuli; (2) the LH is more capable of unimodal and motor processing. While the LH is superior in tasks requiring fixation on a single mode of representation or execution, the RH has a greater neuronal capacity to deal with informational complexity and a greater ability to process many modes of representation within a single cognitive task, suggesting that the RH is better able to activate the entire cortex than the LH and to subserve the functions of both hemispheres--that is, a function of the interaction between the hemispheral roles of "global arousal" vs. "local processing." What's more, it appears that the LH has a greater ability for utilizing previously learned information, while the RH tends approach every task as a novel experience, as though previous learning were irrelevant. In addition, syntax may be said to occupy an intermediate position, in that it is involved with both coordinating elements of surface structure (LH unimodal learning) and serving a functional role, mastery of which may involve RH intermodal integration. The interaction of both hemispheres occurs in every process, such as language, and this is what makes the brain system more advanced. Finally, the "real life" learning situations obviously involve both hemispheres. (edited from the authors' abstract)

Gowan, J.C. (1979). The production of creativity through right hemisphere imagery. Journal of Creative Behavior, 13(1), 39-51.

RH imagery is the vehicle through which incubation produces illumination, insight, and creativity. Imagery occurs in day-dreaming, meditation, creative spells, and relaxation. Historic scientific discovery or invention was mostly through imagery, either in dreams or in a waking state, thus producing the needed

breakthrough for illumination or insight, and the eminences or geniuses of rationality confess to images, dreams, and intuition as sources of their creative discoveries. In addition, RH images are not passive, but have a certain generating and heuristic effect in that they lead to discovery and action. Once this imagery produces insight, then there is intense LH activity to notate, verbalize, describe, and operate this imagery into intellectually negotiable form, so that it can be validated and communicated to others. Finally, RH creativity and LH problem-solving vary in individuals more than any other human traits.

Hirst, W., LeDoux, J., & Stein, S. (1984). Constraints on the processing of indirect speech acts: Evidence from aphasiology. Brain and Language, 23, 26-33.

Examined in this study was the ability of anterior aphasics and patients with RH damage to comprehend both the literal and nonliteral readings of indirect speech acts. The subjects viewed videotaped episodes in which one actor asked a question and another actor responded with either an action or a simple "Yes." The subjects judged whether the response was appropriate given its context. Results indicated that anterior aphasics could comprehend the nonliteral meaning but not the literal reading, supporting models positing that people have direct access to nonliteral but conventional readings. Patients with RH damage could appreciate the direct reading, but failed to distinguish between appropriate and inappropriate action-responses. This finding suggests that it may be possible to dissociate the pragmatic and syntactic aspects of comprehension of indirect speech acts. These findings are relevant to issues concerning the brain organization of language as well as the nature of the comprehension of indirect speech acts. Moreover, the finding that anterior aphasics can differentiate between appropriate and inappropriate actions suggests that they have access to detailed scripts or world knowledge, whereas RH-damaged patients have difficulty assessing and using their scripts of world knowledge to make pragmatic judgements, although LH-damaged patients have difficulty in syntactic components (edited from the authors' abstract)

Jerison, H.J. (1977). Evolution of the brain. In M.C. Wittrock (Ed), The Human Brain. Englewood Cliffs, N.J.: Prentice-Hall.

Environmental factors influence normal brain development, a nature-nurture interaction, for constructing a real world and the meaning of it. In brain evolution, early language contributed to the capacity for imagery rather than communication in the sense that vocalization was equated with shapes, such as geographic maps and events. What's more, people need and use language to tell stories and to produce complex images for listeners/readers, thus demonstrating the role of language as an element in the human capacity to imagine and to experience the real world, both of which are affected by the evolution of language or linguistic forms. In addition, the language-related functions of the brain are inevitably dominant in human performance, emphasizing the unity of the mind through lateral integration of specialized functions from both hemispheres: (1) imagery that is language; and (2) the cognitive contribution to the meaning of an image, whether the contribution arises from verbal-grammatical analysis or from spatial-configurational analysis.

Kapur, N., & Dunkley, B. (1984). Neuropsychological analysis of a case of crossed dysphasia verified at postmortem. Brain and Language, 23, 134-147.

A case is reported of crossed dysphasia in a right-handed monolingual patient, where neuropathological verification of the unilateral site of the lesion was obtained from neuropsychological assessment. The patient's pattern of language impairment was characterized by agrammatic speech and relatively preserved naming ability. In addition, the patient had good repetition, poor comprehension, and marked impairment on visuospatial tasks. Neuropathological investigations showed a large area of damage affecting the cortex, white matter of the corpus callosum, and subcortical structures in the RH. The possibility is discussed of the distinction between two types of crossed dysphasia with either dissociated or simultaneous language and visuospatial deficits due to reversed representation of hemispheric-specific functions or transfer of most cognitive functions to the RH. (edited from the authors' abstract)

Kimura, D. (1973). The asymmetry of the human brain. Scientific American, 228(3), March.

The LH seems highly attuned to the strategies of human communication, a theory supported by the author's findings which indicate that the right visual field for LH processing is superior for both letters and words. Moreover, the author also found that most normal people reported perceiving words through the right ear (LH processing) more accurately than the reverse.

Krashen, S.D. (1977). The left hemisphere. In W.C. Wittrock (Ed.), The Human Brain. Englewood Cliffs, N.J.: Prentice-Hall.

In dichotic-listening research, evidence has been found that the LH is attuned to particular aspects of speech perception, namely decoding speech, and that the LH analyzes the grammatical structure of sentences. What's more, it may also be the case that the RH is involved in some parts of normal language processing, involving the simultaneous analysis of linguistic input in both hemispheres. In fact, not only is there evidence of language processing in the RH, but there is also good evidence that a great deal of nonverbal, time-related processing occurs in the LH, for language perception and production are heavily dependent on the temporal capacities of the LH; temporal-ordered judgements are necessary in syntax, where grammatical relations are often signaled by the sequential order of units. Moreover, what is essentially involved in language production is the programming of an idea, itself containing no intrinsic temporal order, into a sequence of intrinsically unordered linguistic units. Hence, the study of the LH is beginning to extend beyond purely linguistic considerations.

McGlone, J. (1984). Speech comprehension after unilateral injection of sodium amytal. Brain and Language, 22, 150-157.

A unilateral cerebral dominance model predicts that speech comprehension will be disrupted after an injection of sodium amytal into one hemisphere but not after the other. This model was supported when an auditory receptive task involving relatively

nonredundant stimuli was administered to 17 epileptic patients undergoing bilateral hemispheric amytal injections. The findings suggest that phoneme discrimination and decoding processes may be the most crucial features underlying hemispheric lateralization of speech comprehension. The findings also lead to the conclusion that some speech comprehension skills are lateralized in left-handers as in right-handers, and may be more lateralized than expressive skills in language. (edited from the author's abstract)

Metz-Lutz, M-N., & Dahl, E. (1984). Analysis of word comprehension in a case of pure word deafness. Brain and Language, 23, 13-25.

A case of pure word deafness due to left temporal damage is reported. The results of dichotic tests suggest that auditory verbal material may be processed in the RH. The inability to repeat nonsense words, the frequent semantic paraphasias in real-word repetition tasks, and the capacity to give a partial account of the meaning of a word that the patient cannot repeat do show that, despite the impairment of phonological analysis, lexical-semantic processing is possible. An attempt is made to demonstrate that the patient resorts to this semantic processing and that this reflects the linguistic competence of the RH. (edited from the authors' abstract)

Millar, J.M., & Whitaker, H.A. (1983). The right hemisphere's contribution to language: A review of the evidence from brain-damaged subjects. In S.J. Segalowitz (Ed.), Language Functions and Brain Organization. New York: Academic Press.

In a review of research on the contributions of the RH to language, there is the claim that any dependent measure from normal subjects is a product of multiple interactions of both the LH and the RH, rendering it probelmatic to figure out how each hemisphere makes its specific contributions to language. In addition, the LH appears dominant in phonological, sequential, syntactic, and referential functions of language, whereas the RH is more specialized for the experiential aspects of language. Moreover, disturbances in metaphorical speech are related to hemisphere-inattention, in that there is a change in the person's

interaction with the environment and in the way the experience is perceived in the symbolic content of the physical world. In addition, unlike the belief that the RH processes complex linguistic materials, the apparent difficulty for RH-damaged patients to assess the appropriateness of various facts, contexts or situations, and characterizations may indicate a deficit in handling complex ideational materials. Apparently, an intact LH in RH damage does not necessarily ensure adequate comprehension of linguistic messages. Furthermore, anatomical evidence lends support to the hypothesis that the RH is dominant for the comprehension of affective speech. In fact, there is good evidence indicating that the RH contributes to many factors of human behavior that play some role in communication, such as affective behavior in appreciating humor, imagery, & visuospatial processing which is more cognitive-affective than linguistic. What's more, the RH is especially involved in the relationship between language and perceptual plus emotional processes on which metaphorical speech is dependent. And because visuospatial processing is vulnerable in RH damage, it is suggested that verbal-sequential operations depending on visuospatial functions may be affected secondarily in RH damage. Finally, in early childhood LH damage, evidence indicates that phonological and semantic systems transfer very well to the RH.

Molfese, V.J., Molfese, D.L., & Parsons,C. (1983). Hemisphere processing of phonological information. In S.J. Segalowitz (Ed.), Language Functions and Brain Organization. New York: Academic Press.

Investigators have shown a right-ear advantage (LH) for words, and a left-ear advantage (RH) for nonspeech material, such as vocal nonspeech, music, and environmental sounds. Although the right-ear advantage for speech is due to a stronger signal arriving at the hemisphere specialized for language processing, researchers believe that both hemispheres have the ability to extract the acoustic properties of speech, and processing of temporal information would appear to involve bilateral mechanisms of both hemispheres. The different, perceptually important cues for speech perception seem to be subserved by different regions of

the whole brain. In fact, analysis of electrophysiological responses indicates that each speech cue is processed by a number of distinct mechanisms, some of which are bilaterally represented and others which are lateralized to one cortical region. These findings suggest that there is some degree of redundancy in the cortical mechnaisms involved in speech perception. Clearly, then, it would appear that language perception must depend on multidimensional and complex processes rather than solely on either LH or RH processing.

Rugg, M.D. (1983). Further study of the electrophysiological correlates of lexical decision. Brain and Language, 19, 142-152.

In a study on discriminating between words by employing two tasks based on a visual code and a phonological code, the data support the author's suggestion that the prerecognition processing of letter strings of words gives rise to parallel visual and phonological processing which, in the case at least of visual processing, is distributed over both hemispheres.

Sagan, C. (1977). The Dragons of Eden. New York: Ballantine Books.

There is no way to tell whether patterns extracted by the right hemisphere are real or imagined without subjecting them to left hemisphere scrutiny. On the other hand, mere critical thinking, without creative and intuitive insights, without the search for new patterns, is sterile and doomed. To solve complex problems in changing circumstances requires the activity of both cerebral hemispheres: the path to the future lies through the corpus callosum. (pp.190-191)

Segalowitz, S.J., & Bryden, M.P. (1983). Individual differences in hemispheric representation of language. In S.J. Segalowitz (Ed), Language Functions and Brain Organization. New York: Academic Press.

Differences among individuals in brain morphology and in developmental experiences affect characteristics of language function, which may affect the way language comes to be organized in the brain, thus influencing the cognitive framework of the

individual's language. The varying cognitive processes involved in language use may have varying intrahemispheric and interhemispheric relationships, and researchers must accept the notion that there are wide differences in hemispheric activation. From the clinical literature, every human brain is unique in the fine detail of its structure and organization. Much of the neurolinguistic literature now deals with such fine detail as specific aspects of phonological, syntactic, and semantic systems.

Sergent, J. (1984). Processing of visually presented vowels in the cerebral hemispheres. Brain and Language, 21, 136-146.

The respective efficiency of the cerebral hemispheres in processing visually presented vowels is discussed and examined in a tachistoscopic experiment with normal subjects. It is suggested that results from dichotic listening experiments cannot be used to predict performance on the same material in the visual modality. The physical characteristics of the stimulus, in both modalities, contribute to the pattern of hemispheric advantage and cannot be ignored in the interpretation of results from dichotic listening and tachistoscopic experiments. (from the author's abstract)

Shucard, D., Cummins, K.R., & McGee, M.G. (1984). Event-related brain potentials differentiate normal and disabled readers. Brain and Language, 21, 318-334.

Auditory event-related potentials (AERPs) recorded to irrelevant tone pairs while subjects performed visual, reading-related cognitive tasks differed significantly between normal and disabled readers. Disabled readers as compared with normal readers showed significantly lower amplitude right hemisphere AERP responses during tasks involving visual-phonemic transfer of information and simple pattern recognition. Disabled readers as compared with normal readers showed significantly higher amplitude left hemisphere responses during the visual-phonemic task. In both experiments the reading disabled subjects showed significantly lower amplitude right than left hemisphere AERP responses, activating different cerebral processes. (edited from the authors' abstract)

Stroh, C. (1982). Creativity and the split-brain: An artist's view. The Midwest Quarterly: A Journal of Contemporary Thought, 24(1), 68-76.

The brain is highly resilient and appears to "cross reference" so that functions identified with one area of the brain can be accommodated by other areas. Moreover, research has shown that there are some language capabilities in the RH, such as naming skills. In communication, neither language nor visual images operate very well alone. Visual images and linguistic categories cannot be separated in perceptual experience. What's more, any discussion of art as a RH activity is misleading and incomplete if the discussion doesn't also acknowledge interdependence of each hemisphere on the other. In addition, psychologists generally accept the theory that there are four stages of creative behavior: (1) "preparation" in which one collects data from experience or research and files the information into mental categories in memory, requiring interaction of both hemispheres; (2) "incubation" which allows the mind to let data "float free" without any attempts to organize or apply the information, particularly occurring in the RH; (3)"illumination" in which a new idea and insight are discovered or a solution is found, basically an RH activity; and (4) "verification" which involves modifying,adapting, and synthesizing the other three stages to produce the artifact, thus involving continual hemispheric overlap, interaction, and transaction between words and images, as the whole process doubles back on itself in a circular fashion since both hemispheric functions are mutually reinforcing.

Vaid, J. (1983). Bilingualism and brain lateralization. In S.J. Segalowitz (Ed.), Language Functions and Brain Organization. New York: Academic Press.

The available clinical and experimental studies suggest that competence in more than one language may influence brain functioning so that it differs from that characterizing speakers of a single language. Focus on the theoretical issues bears upon the problem of cerebral-hemisphere correlates of language processing in bilinguals. Following a general summary of clinical and experimental findings, specific studies are discussed with a

view of addressing whether and why factors intrinsic to bilingualism might influence the extent to which the LH and the RH partake differently in language processing. On the basis of clinical studies, it has been proposed that the RH in bilinguals may share language functions with the LH to a greater extent than in the case of hemispheric unilaterals. An implication for language processing is that both hemispheres contribute to it. They only differ in the nature and degree of their contribution. The evidence does suggest that RH participation is more likely when the second language is acquired later in relation to the first language, as well as the more informal the exposure is to the second language. On the other hand, LH involvement is more likely when the second language is acquired earlier in relation to the first, in addition to a more advanced stage of acquisition and a more formal exposure to the second language.

Valsiner, J. (1983). Developmental specialization and integration in child development. In S.J. Segalowitz (Ed.), Language Functions and Brain Organization. New York: Academic Press.

It is a conceptual fallacy that language functions are solely organized in the left hemisphere of the brain. Information processing may function in both hemispheres of the intact brain at the same time. The brain is a far more complex system than a simple, two-compartmental (LH and RH) "black box," and there is no reason to generalize from input hemispheric lateralization to lateralization of information processing. What's more, it is a tradition in Russian neuropsychology and neurophysiology to look at the functioning brain as a complex system of interdependent subsystems. This kind of general, "holistic-system-theory-approach" has been accepted in psychology as well as in neuro-physiology. According to this view, speech is organized in the brain by a complex functional system uniting different areas of brain processing. Neurophysiologically, different functional systems are based on complex aggregrations of neurons. Moreover, hemispheric dominance and asymmetries in brain functions are a highly flexible phenomenon dependent upon an environmentally given task and the present emotional-motivational state of the

subject. In addition, brain growth occurs in a nonlinear sequence with nonlinear reorganization of different subsystems. Finally, it may be heuristically worthwhile to study the conditions under which hemispheric dominance for certain tasks can be shifted from one side of the brain to the other, and visa versa; shifts in lateralization of the hemispheres could be well connected to the ease of assimilating stimuli (establishing a connection between the new stimulus and former experience), which can be based on individual interest of the subject as well as on learning.

Wapner, W., Hamby, S., & Gardner, H. (1981). The role of the right hemisphere in the apprehension of complex linguistic materials. Brain and Language, 14, 15-33.

A battery of tests was administered to a population of RH-damaged patients, as well as to control groups of normal subjects, in order to assess their sensitivity to narrational and humorous materials. The results of the tests suggested that the RH-damaged patients, unlike the control groups, exhibited special difficulty in processing complex linguistic entities and in using the surrounding context to assess linguistic messages, thus supporting earlier studies and clinical observations. While these RH-damaged subjects maintained the ability to remember isolated details and wordings, they had clear difficulty with integrating specific information, with drawing proper references and morals to stories, and with assessing the appropriateness of various facts and situations or contexts. Furthermore, the RH-damaged patients had problems in acquiring overall gestalts or forms of linguistic entities, in addition to recurring difficulties in the ability to conceptualize the unit of discourse as a whole, to appreciate its purpose and its form, and to integrate specific elements appropriately within these forms. Correlatively, many of these patients, though appearing to retain the basics of language, seemed to be insensitive to a full understanding of the context of an utterance, in which these linguistic entities are produced and used: the presuppositions entailed or the tone of a conversational exchange. It was further suggested that the LH is characterized as the "straight aspects" of language: phonology,

syntax, and literal lexical entities, all of which may require sheer computational capabilities. What's more, the LH is a place for the ideal "content free" situation: a simple assessment of whether a word is spelled or defined correctly and whether a sentence is syntactically acceptable. On the other hand, the RH is arrayed with more complex linguistic entities, ones which entail redundant information, nonliteral information, and information requiring integration across the boundaries of words and clauses; in the RH, there are situations in which contextual information is wholly or largely determinant, such as understanding the underlying intention of a comment, thus constituting pragmatic features contributing to the comprehension of linguistic material. Finally, one other explanation about the RH's abilities is that it handles complex ideational materials rather than complex linguistic materials.

Whitaker, H.A., & Ojemann, G.A. (1979). Lateralization of higher cortical functions: A critique. In S.J. Dimond & D.A. Blizard (Eds.), Evolution and Lateralization of the Brain. New York: New York Academy of Sciences.

Offered is a convincing argument that hemisphere differences as assessed in commissurotomy patients are inappropriate models of functioning for the normal human brain, since the possibility of drastic cortical reorganization cannot be eliminated. Thus, it is impossible to know the extent of trauma or damage caused by surgery.

Witelson, S.F. (1983). Bumps on the brain: Right-left anatomic asymmetry as a key to functional lateralization. In S.J. Segalowitz (Ed.), Language Functions and Brain Organization. New York: Academic Press.

Linguistic skills are conceptualized as being mediated predominantly by the LH because these skills are heavily dependent on the analytic-temporal mode of information processing. However, the RH is now clearly documented to be dominant as not just the "nonverbal" hemisphere; its relatively specialized function may be described as one in which information is processed

so that stimuli are synthesized or unified into a holistic precept and in which the temporal aspects of stimuli are superceded. The perception of spatial relationships, regardless of the sensory modality involved, appears to depend mainly on this RH type of cognitive processing. Moreover, there is variation in the direction of functional hemispheric lateralization, as, for example, in right-handers vs. left-handers; some left-handers, possibly those having a history of familial sinistrality or having inverted hand posture, appear to have somewhat less lateralization of language function and a greater degree of bihemispheric representation of language. Finally, some aspects of cognitive function (analytic-temporal or synthetic-spatial) may have a biological basis in the hemispheres of the brain.

Young, A.W., Ellis, A.W., & Bion, P.J. (1984). Left hemisphere superiority for pronounceable nonwords, but not for unpronounceable letter strings. Brain and Language, 22, 14-25.

Right-handed adults were asked to identify bilaterally presented linguistic stimuli under three experimental conditions: (1) stimuli were three-letter pronounceable nonwords, and subjects were asked to name them; (2) stimuli were three-letter pronounceable non-words, and subjects were asked to report them as letter strings; and (3) stimuli were more or less unpronounceable letter strings created by rearranging the letters of pronounceable nonwords, and subjects reported them as letter strings. Pronounceable nonwords were found to be better identified from the right visual hemifield irrespective of the way in which they were reported. Unpronouceable letter strings did not produce any visual hemifield difference. Nonwords are of interest because they can be seen as potential words lacking both specific semantic properties and entries in the subject's internal lexicon. The results of the experiment are consistent with the view that both the LH and the RH are able to identify letters, but the LH is more sensitive to the particular pronounceability of the nonwords. This may happen either because the LH can make better use of resemblances to real words or because it has access to the spelling-to-sound correspondence rules. (edited from the authors' abstract)

*Educational Implications of Brain Research Related to Teaching the Language Arts in Reading, Writing, and Oral Communication

Bogen, J.E. (1977). Some educational implications of hemispheric specialization. In M.C. Wittrock (Ed.), The Human Brain. Englewood Cliffs, N.J.: Prentice-Hall.

In light of the LH's dominance in language skills, the obvious need for RH spatial skills in the LH act of reading is ignored. And to characterize RH appositionality as synthetic also ignores the synthetic aspects of language formulation. Although the LH is considered dominant for speaking, reading, and writing, the RH is not nonverbal because split-brain studies show the RH to have considerable verbal ability, such as some syntactic capacity. It is also an error to consider the RH as less "semantic" than the LH. In addition, the notion of two largely lateralized modes of thought suggests that teaching by either lecturing or by imitation affects primarily one or the other hemisphere. The learning of almost any idea is likely to be better if both methods are used. This means that teaching solely by "example" is open to the charge of one-sidedness, as would be a curriculum solely of lecture courses. Since education is effective only insofar as it affects the working of the entire brain, educators can see that a school program narrowly restricted to reading, writing, and math will educate mainly one hemisphere, leaving half of an individual's high-level potential unschooled. Giving equal time to each hemisphere saves from neglecting a cognitive potential as important for high-level problem solving as for language skills. What's more, it is believed that hemispheric specialization tends to be more "process-specific" rather than "material specific," suggesting that the subject matter may be less important than its method of presentation. Thus, greater RH participation would involve more laboratory and field experience at the expense of lectures and seminars. Moreover, the decrease in reading ability may result in part from inhibiting language ability, depending upon the activities to which the relevant parts of the brain are exposed. Finally it may be a principle virtue of these findings about the brain to serve as scientific support for a more diversified educational curriculum.

Botkin, J.W., et al. (1980). Towards more effective teaching and learning: What can research in the brain sciences contribute? A survey of some recent research efforts and their implications for education. International Center for Integrative Studies, New York, September. (ERIC Document Reproduction NO. ED 225 191)

From LH and RH studies, an important implication of brain research is that educators must focus on the whole learner, viewing the brain not as two halves but as one whole, in a "holistic education" for lateral integration of both hemispheres. One implication of the LH-RH "polar opposites" view is to search for ways to develop or remediate which ever side of the brain is underdeveloped. However, this remedial approach is limited in two ways: (1) educators still lack adequate descriptions about what each hemisphere does (e.g., the RH does have some language capacity and both hemispheres process images);(2) differences across individuals may vary considerably, and identifying such differences through "standardized testing" may lead to labeling some people as inadequate because they fail to conform to certain standard patterns, resulting in stereotyping which may be costly.

Bull, B.L., & Wittrock, M.C. (1973). Imagery in the learning of verbal definitions. British Journal of Educational Psychology, 43, 289-293.

In this study, one group of students copied definitions on vocabulary items; one group read definitions; and one group traced pictures that showed definitions. Test scores on recall were superior for the group that traced pictures. The study indicated the use of pictures for vocabulary learning, especially pictures created inside the readers' brains.

Chall, J.S., & Mirsky, A.F. (1978). The implications for education. Education and the Brain, 371-378. Univ. of Chicago Press.

Environmental stimulation and experience play central roles in the growth and development of the brain. In matching teaching with learners' aptitude for efficient learning, educators must be aware of the great importance of LH and RH interaction for developing human cognition and for developing an understaning of

the differences in learning styles. Two strong implications for education are (1) finding out how to strengthen weak LH processes of some students by using more RH activities to help them learn LH skills and (2) teaching students with weak academic skills, in a curriculum based on LH processing, to use other activities involving RH functions.

Claycomb, M. (1978). Brain research and learning. National Education Association, Washington D.C., August. (ERIC Document Reproduction No. ED 200 562)

The LH and RH "division-of-labor" theories attribute functions to specific regions of the brain. These theories lead to the conclusion that educators must be concerned with educating all areas of the brain, since all of these areas interact. The brain research suggests that a basic education must include information-processing skills, in addition to nonlogical, creative, artistic activities. Moreover, interaction of the hemispheres indicates that LH and RH functions can, and should, be developed in students appearing to be oriented toward a single hemisphere. In fact, individualized instruction and approaches to learning are also emphasized because of the many differences in modes of brain processing, since students cannot fully enjoy the right to learn until they are offered learning conditions that take into account their individuality. Finally, for promoting lateral integration, the author emphasizes the audio-visual media: T.V., films, cassettes.

DeJarnette, G. (1983). Neurogenic communication disorders and paralleling agraphia disturbances: Implications for concerns in basic writing. Paper presented at the meeting of the Conference on College Composition and Communication, Detroit, March. (ERIC Document Reproduction No. ED 229 793)

Lateral integration of the hemispheres permits cognitive-linguistic associations; that is, the conceptual programming of language output is a by-product of lateral integration, a whole-brain activity involving sensory perceptions, memory, and cognitive processing for generating feelings, ideas, and desires to be expressed, thus integrating external (auditory/visual) and

the internal (cognitive processes) stimuli for generating thought. In oral and written language, one must be capable of attending (perceiving and discriminating), retrieving associative information from memory, and translating thoughts into outward expression (recoding and encoding). The speaker/writer must be knowledgeable of linguistic constraints on content (semantic/meaning), form (phonetic, graphemic, and syntactic), and use (pragmatics) in speaking and writing. What's more, although oral and written language share neurolinguistic processes of activation, writing is still the highest form of linguistic symbolization, requiring tacit awareness of and formal training in language constructs. A writer must develop a metalinguistic awareness or sense about the act of writing; that is, he/she must be able to express inner thoughts by making conscious choices about unconscious linguistic functions, and a writer must have facility in text cohesion, style, vocabulary, semantics, syntax, spelling, and an awareness of the audience's needs so that old and new information are relevantly, cohesively, and coherently shared.

Fox, P.L. (1979). Reading as a whole brain function. The Reading Teacher, 33(1), 7-14.

The author hypothesizes that, according to Frank Smith, reading is "generative" processing and that humans complete sentences and pictures from experiences, anticipating meaning based on prior knowledge of semantics, syntax, and the subject matter. Thus, with increasing skill, readers depend less on decoding skills and more on "generative skills." Successful reading, moreover, requires the integration of the two hemispheric modes of symbol processing available to the mind: logic/intuition, analysis/synthesis, pedantry/creativity. Good readers also seem to integrate the verbal (LH) and the visual (RH) aspects of reading unconsciously; consequently, exercises in visualizing may be valuable for tapping the RH, thus enhancing reading skills in LH processing. In fact, RH techniques can be easily incorporated into vocabulary learning, literal comprehension, and nonliteral comprehension (internalization of theme). As in picture recognition, the RH apprehends the global characteristics of a concept and gives

it meaning. So a number of investigators have found that the use of imagery can stimulate vocabulary learning and comprehension because it seems that the RH's facility for organizing verbal material pictorially can significantly improve comprehension in normal readers.

Frostig, M., & Maslow, P. (1979). Neurological contributions to education. Journal of Learning Disabilities, 12, 538-552.

Movement involving all brain functions, including emotions, should be a part of any educational program. And because emotions cannot be divorced from cognitive abilities or from attention and concentration, the classroom atmosphere must be warm, supportive, and positive, and each student's interests and concerns must be taken into account. In addition, students must be encouraged to be active learners; only if students are actively engaged in learning, and not only the passive recipients of the teacher's imparted information, will they be motivated maximally to develop their cognitive abilities. This is true because learning and adapting influence the brain's structure and function, for the brain cannot operate without the person learning from, adapting to, and acting upon the environment; therefore, learning is an active process, with both hemispheres nearly always functioning in a healthy brain. Accordingly, the teacher must help students integrate the intramodal and intermodal stimuli processes of both hemispheres, since skilled movements require the concerted neural activity of both halves of the brain. In writing, moreover, the LH is responsible for verbalization, while the RH is mainly responsible for the correct use of space in letter and word formation. What's more, reading becomes mainly a visual task in terms of whole-word and whole-phrase reading. Consequently, the person who learns best visually will be helped to remember information when guided by imagery (RH). And the person who learns best verbally, and has a good memory for sound, does best by trying to remember the sound of words and their meaning (LH). Finally, in educational approaches to LH deficits, using visual material in presenting information, especially for vocabulary and reading, helps students make associations between the visual stimuli and the words to be learned.

Gannett, C., & Diller, K. (1981). Process and pedagogy in writing: Neurolinguistic considerations. Working draft. Paper presented at the meeting of the American Association of Applied Linguistics, New York. (ERIC Document Reproduction No. ED 219 955)

Because of neurolinguistic evidence in "alexia without agraphia," there are claims that reading and writing as neuropsychological processes are partially separated and not identical, or not simply inverse processes of each other, for reading and writing are not always equally impaired after damage to the language-dominant LH. Though reading and writing are highly interactive, sharing some of the same neuropsychological processes, the decoding and encoding involved are not symmetrical. In addition, the syndrome "alexia with agraphia" is caused by a lesion in the angular gyrus of the LH's parietal lobe, impairing the reading, writing, and spelling processes. What's more,"Broca's aphasia" gives evidence suggesting that reading and writing are neurolinguistically distinct in certain respects because reading comprehension is possible inspite of severe grammatical problems, whereas writing with no grammar is much more severe. Thus, neurolinguistic evidence suggests that competence in reading doesn't have to precede acquisition of writing, since the two processes can be made to be somewhat independent of the other, although the processes of composing are more complex. Consequently, strong educational arguments can be made for teaching writing first because, if mastery of the print code is the primary goal, then writing (encoding) is the process in which mastery of the code is more essential. But sound educational practice in most settings would be to teach writing and reading at the same time.

Gazzaniga, M.S. (1977). Review of the split brain. In M.C. Wittrock (Ed.), The Human Brain, Englewood Cliffs, N.J.: Prentice-Hall.

Special testing of Dr. Roger Sperry's split-brain patients showed that the RH has a rich mental life of its own and is capable of experiecing most of the activities of the LH. Gazzaniga and Sperry conducted nonverbal tests on these patients and found that the RH does have some language function and can emote, learn, and remember. Evidence from this split-brain research may hint at

some redundancy in the brain system during the normal-development process, suggesting that language and spatial functions are not strictly or exclusively lateralized to the respective LH and RH. Hence, the educational implications include the following: (1) a student who has talents in visual-spatial relations may have problems in a verbal-articulatory mode of solving conceptual problems, thus encountering difficulty and frustration in the learning process; (2) a student with high verbal skills may be unable to visualize the spatial aspects of an assigned task; and (3) being aware of a student's specialized visual-spatial skills (RH) or verbal skills (LH), a teacher thus informed will be enormously aided by knowing how best to present materials in class and to obtain speedy comprehension on the student's part, with proficient use of the instructional materials.

Hardyck, C., & Haapanen, R. (1979). Educating both halves of the brain: Educational breakthrough or neuromythology? Journal of School Psychology, 17, 219-230.

The increasing popularity of the notion that the two hemispheres of the cerebral cortex carry on different functions and modes of thinking has accelerated social and commercial pressure to organize school curricula, teaching, and testing in order to conform to a RH-LH dichotomy. Evaluated and reviewed is evidence gathered from commissurotomy (split-brain) patients and RH-LH studies on normal brain-intact subjects. From this review of research are the following conclusions: (1) the commissurotomy patients are not suitable subjects on whom to base generalizations about cortical functioning in the normal brain-intact human; (2) the LH and RH differences reported in many experiments on normal subjects are small and can be found only in an extremely narrow experimental context; and (3) there is no scientific basis in this brain research for any reorganization of the curricular, teaching, or testing programs within contemporary educational practice.

Hart, L. (1975). How the Brain Works: A New Understanding of Human Learning, Emotion, and Thinking. New York: Basic Books.

A significant portion of the neocortex is structured toward oral language, as well as reading and writing, and thinking aloud is necessary for expanding neural capacity.

Hart, L.A. (1978). The new brain concept of learning. Phi Delta Kappan, 59, 393-396.

The "proster theory," from recent findings of brain research, offers a brain-compatible approach to learning, which emphasizes that the brain seeks what it needs for adapting to reality and that processing is individual, depending less on presenting material to be learned than on the total, previously stored experience of the learner. In addition, since a great portion of the brain is devoted to language, students must talk in order to learn as well.

Hart, L.A. (1979). Brain, language, and new concepts of learning. Educational Leadership, 38, 443-445.

Healthy, normal children probe, explore, examine, investigate, and test until they are forced to sit still at a school desk and listen, which are brain-antagonistic conditions causing learning to come to a halt, in addition to learning failures, discipline problems, frustrations, and boredom. Moreover, psycholinguistics and the neurosciences show that the brain is constantly active and highly aggressive, but it is the teacher who turns out to be active while the students are passive, usually listening. What's more, it is emphasized that students must actively talk to learn best; a "stop talking" environment is likely to be a "stop learning" environment. Finally, rote instruction and learning right answers have become inadequate and even harmful, viewed as a brain-antagonistic condition, but the educational system was designed for rote learning, not for a brain-compatible education.

Hatcher, M. (1983). Whole brain learning. School Administrator, 40(5), 8-11.

The brain is a circuitry of interconnecting neurons or nerve cells, and thinking is actually the neural process of synaptic action in which knowledge takes place. Research indicates that the brain is composed of 10 to 100 billion neurons constantly firing and exchanging information among themselves. Although each hemisphere has specialized functions, there is a bilaterality in the brain, meaning that each hemisphere also shares some functions and participates in most activities, simply processing information differently. Information in the RH is stored in images, senses, symbols, and metaphors, and the LH must recognize and reformulate RH images into words for communication. What's more, LH works with stimuli already known and is unable to create meaning or to generate new ideas. Interestingly, it is from the RH that new ideas, total contexts, and creation of meaning emerges, without which there would be no ideas. But without the LH, the idea would not be encoded, understood, and communicated. In addition, traditional education has emphasized LH functions to the neglect and denial of the RH, especially for creative people who perceive holistically rather than analytically, leaving them with little opportunity to achieve well on LH-oriented I.Q. tests. Recently, however, biomedical scientists, psychologists, and educators have sought to advance brain research and use it to improve learning in order to balance both hemispheric modes in teaching. Techniques to tap RH power are offered: (1) synthetics focuses on metaphorical thinking to see patterns and to detect meaning in part-whole relationships, thus bridging the RH with the LH; (2) multisensory/discovery/ experiential learning involves "learning by doing," providing the RH with stimulus to activate and bridge whole-brain function; (3) creative thinking involves solving open-ended problems, asking the right questions instead of giving the right answers, discovering, and exploring gestalt techniques. Also, emotional closeness in enriched experiential learning environments promotes the myelin production of neurons for increased thinking and learning capacity, illumination, insight, and creativity. Finally, research shows that the brain efficiently processes only information that is helpful, interesting, and rewarding to learners.

Kirk, U. (1983). Language and the brain: Implications for education. In U. Kirk (Ed.), Neuropsychology of Language, Reading, and Spelling. New York: Academic Press.

The research reported suggests that language, reading, and spelling are complex, interactive, multilevel functions of the brain, requiring for their operations the integrated contribution of multiple neural systems and subsystems with intra and inter-hemispheric pathways involved, as each hemisphere contributes to the complex cognitive activities of speaking, listening, reading, and spelling; the focus is on an integrated, bilateral, and multimodal hemispheric process rather than a lateralized brain. The intact brain is composed of reciprocally concerned structures, multiple feedback loops, and "upstream-downstream gating mechanisms." What's more, information is not directed or confined to either one hemisphere, and skilled performance is associated with integrated rather than one-sided hemispheric functions. And since the brain system is designed for action, the most efficient learners are not passive absorbers; rather, they are active participants in the learning process; therefore, learning is an active and constructive process rather than a passive one, involving the actions of the whole brain. For instance, spelling and reading require both phonemic knowledge (LH) and the use of visual gestalts (RH). And since there is no evidence to support the view that education can be directed to one side of the brain, both hemispheres are engaged in classroom learning. What's more, the ability to create meaningful order and to pose questions may be more crucial to academic success than to master preorganized, redundant information. Finally, close attention should be given to students' multiple learning styles in order to integrate the modes of both hemispheres.

McLendon, G.H. (1983). Recent research into the hemisphericity of the human brain and the implications of those findings in the teaching of reading. Viewpoints. (ERIC Document Reproduction No. 239 228)

Recent data from neurosurgery, neuropsychology, and neurolinguistics indicate that the brain is lateralized toward two methods of information processing, and language bias appears to be a function of the LH, while visual-spatial bias is a RH function. Moreover, the

LH perceives and processes information in parts, and the RH in wholes. Researchers in studies on the teaching/learning process have discovered that readers who process information, such as written material, by using the LH strategy of sequencing (time and detail) may be able to read but not comprehend. Readers having good visualization skills (RH), but lacking the sequencing skills of the LH, have great difficulty developing overall reading skills. In light of these findings, the educational challenge is to teach the whole student, approaching each hemisphere's processing strengths with exercises allowing integration of perceptual strategies in reading in order to produce holistic thinkers. In fact, neurosurgery, psychology, and linguistic research indicates that students should be trained as creative readers by processing words in a holistic fashion. From studies, it seems that the strengths of readers with RH bias can be used to approach the written material by using visual strategies, such as pictures, to allow those readers to develop LH sequencing skills.

Nebes, R.D. (1977). Man's so-called minor hemisphere. In M.C. Wittrock (Ed), The Human Brain, Englewood Cliffs, N.J.: Prentice-Hall.

One theory of hemispheric specialization proposes that the LH handles skills in which stimuli are familiar and verbal in nature. On the other hand, the RH excels in tasks involving shapes and spatial relationships too complex to describe in words. Educational implications of this theory suggest that, if the RH does process data differently from the LH, then educators may be short-changing themselves by teaching LH talents of verbal skills at the expense of nonverbal capacities and creativity of the RH. Many problems can be solved by analysis (LH) or by synthesis (RH); but if students are taught to examine only one approach, then their ability to choose the most effective and efficient answer might be diminished. Increased understanding of how the RH works will hopefully lead to better training in how to use both hemispheres and their skills of processing information in learning.

Roberts, D.H. Neurological processes and reading pathology: Knowing about children and reading dysfunction. (ERIC Document Reproduction No. 218 600)

Theoretically, there are more than 2.0589×10^{60} bits of information in the fully programmed brain, explaining why the language competence of humans can generate sentences to express an infinite number of thoughts in an infinite number of ways. In addition, researchers have combined psycholinguistic and neurolinguistic methods to suggest that learning to use the graphic code (grapheme-phoneme rules) comes only after knowing the corrspondence between acoustics and the graphic code. What's more, in the functional brain organization of normals, larger interhemispheric coherence occurs over the parieto-occipital regions, suggesting that normals' hemispheres share a great deal of language information in reading. Finally, Computerized Axial Tomography (CAT Scan) gives support to the hypothesis that learning to read involves gestalt perception in RH processing.

Straham, D.B., Toepfer, C.F. (1983). The impact of brain research on the education profession: Agents of change. Journal of Children in Contemporary Society, 16, 219-233.

In empasizing analogical-nonverbal as well as logical-verbal thinking and learning, thinking enrichment efforts must include experiences in image-mediated activities, artistic endeavors, and visual-imagery strategies. In addition, discussed is an EEG procedure in which researchers analyzed students' thinking during two different modes of writing: conveying a message and expressing feelings. The results demonstrated that while the writing product is linear, the composing processes incorporate nonverbal and non-linear modes of thinking. What's more, evidence suggests that when tasks are simple, bilateral brain activation is at a low level, and the brain seems to rely on one hemisphere, receiving little facilitation from the other side. If this is the case, then "active learning" can only result when the "whole brain" is aroused and engaged, suggesting that teachers provide meaningful challenges to their students, not overload, Moreover, the issue of professors as teachers rather than lecturers has also been a

big concern in terms of active learning vs. passive learning. Finally, educators must explore areas in which learning can be offered in styles and modes of processing more common in RH-dominant learners, such as the mobility of computer graphics for visual-spatial preferences.

Sywester, R. (1981). Educational implications of recent brain research. Educational Leadership, 39(1), 6-9.

Educators need to understand the brain that really defines the profession and to introduce students to their brains. Brain discoveries may encourage teachers to move away from the traditional "proactive/group/normative" approach with students towards a more "reactive/individual/diagnostic approach of individual education plans: scheduling students individually, in addition to focusing on individual diagnosis and instruction.

Torres, C., & Katz, J. (1983). Neurolinguistic programming: Developing effective communication in the classroom. Teacher Educator, 19(2), 25-32.

Neurolinguistic Programming (NLP) is a method teachers can use to communicate effectively at the level of their students. The basic premise of NLP is that there is a pattern to each person's communication because each has a predominant sense through which he/she receives information and experiences the world and which is communicated to others through language. These major input channels are visual, auditory, and kinesthetic senses. People either see (visual) pictures or images of their experiences, or they hear (auditory) sounds and talk about their experiences, or they experience (kinesthetic) and have feelings about their experiences. By looking at the predicates (verbs, adjectives, and adverbs) that students use, teachers can decide which representational system with which the students use to communicate. The teacher then can open up lines of communication by speaking in the same mode of the student. NLP is also effective for the classroom because once the teacher becomes aware of the predicates used in all the students' patterns, he/she can make an effort to teach and explain in all modes. (from the authors' abstract)

Webb, G.M. (1983). Left/right brains, teammates in learning. Exceptional Children, 49(6), 508-515.

Neither the LH nor the RH is better or less able than the other. The RH does perform some language tasks at concrete levels (e.g., naming nouns and verbs), while the LH performs concrete visuo-spatial tasks. There is no convincing evidence for absolute control of any psychological process by either hemisphere, and there may be relative rather than absolute contributions from the two hemispheres. The LH and the RH work cooperatively to create a fully rounded view of the world. Learners who use both brains cooperatively fare best academically. Addressing teaching to either the LH or the RH deprives the learner of the whole conceptual experience; i.e., synthetic reasoning of the RH needs LH language to express ideas effectively. To achieve lateral integration, introduce a task visually and translate it into language (e.g., picture, T.V.). Ask the visual learner the what, when, where, how, and why of each experience or activity. Encourage the learner to talk by asking and answering questions in peer groups, thus building understanding and creating situations for expressive language. To build writing skills using a visual base, give students a picture and ask them to examine it carefully and to write a paragraph describing what they see. To be truly competent, independent, and effective learners, students need to team both hemispheres. And since analysis (LH) and synthesis (RH) are parallel strategies in information processing, both are foundational to inductive and deductive reasoning, to critical thinking, and evaluative decision making. Perhaps the need to analyze, to synthesize, and to problem solve in a technological society is the reason for teaming both hemispheres.

Weis, M.R. (1982). Current brain research and the composing process: A call for interaction. CEA Critic, 44(2), 22-28.

It is suggested that the RH is capable of both interrelated and independent activity as a component of the composing process, with a need to encourage the creative and intuitive aspects in writing and to develop functional heuristic procedures to help students get insightful ideas down on paper, not only involving logical-

analytic ordering of the LH, but also engaging the intuitive patterning process of the RH, both of which can be taught as well as learned. In addition, brain research indicates that the composing process is not linear but recursive because the whole process of writing demonstrates the recursive quality of thinking that is actualized by the interplay of the RH and the LH's activity. What's more, when the mind is free from logical thought and analytic judgement, as in argumentation essays, RH holistic perception, flashes of insight, and new discoveries then come to the mind. Accordingly, methods of activating the RH intuitive function are as follows: (1) posing or stating a question or problem; (2) stating a hypothesis; and (3) projecting answers in exploring the topic, essential for recalling experience, getting it clear, giving it shape and making connections, in addition to speculating and building theories. With guidance in heuristic procedures strengthening RH activity, students select and arrange data from their experiences, reaching insight at some moment when they discover what they really want to write about for describing an experience to an audience; that is, students gain insight into how language shapes and gives meaning to experience. As for heuristic procedures to encourage flashes of insight, brainstorming, freewriting, and problem-solving must be more than a memory retrieval aid and must have sufficient time for the recursive stages of rhetorical invention, suggesting Elbow and Macrorie's approaches of freeing students to write sufficiently. What's more, it is also suggested to use visual stimuli in the classroom before composing or the holistic effect of music as directed stimulus to creative thinking. Finally, teachers need to make students aware of and comfortable with the recursive nature of the stages of invention during the composing process, in addition to teaching the interactions of the LH and the RH, so that students don't freeze of feel inadequate in their writing and can shape or give meaning to their world, according to their own intuitive patterning.

Wenger, W. (1981). Creative creativity: Some strategies for developing specific areas of the brain and for working both sides together. Journal of Creative Behavior, 15(2), 77-89.

The main language of the "right parietal lobe" is composed of sensory images or impressions. What's more, the main way to develop conscious, verbal-brain awareness is to describe something aloud to a listener while one is observing it, thus discovering more about it. Far greater discoveries result by describing images aloud, developing a conscious awareness of responses from the right parietal lobe. The author suggests to word-paint a picture in terms of color, shape, texture, and feelings of an impression that will cause the listener to experience it also. In group discussion, exchange reactions and observations of natural responses to this word picture experience in order for the writer to get feedback. Stretching one's ability to describe develops the connectedness with the RH. And verbalizing some rich or unusual experience while observing it develops the LH and sophisticates one's command of the language by using visual thinking, the most rewarding and effective mode of thinking known.

Wittrock, M.C. (1977). The generative process of memory. In M.C. Wittrock (Ed.), The Human Brain, Englewood Cliffs, N.J.: Prentice-Hall.

The author emphasizes that the cortical hemispheres overlap greatly in function and are richly connected with each other through the cerebral commisures and other tissues. The so called dichotomy between hemispheric functions probably results because of the slight advantage one strategy has over another, which is sufficient to produce specializations of some functions. Research indicates the importance of understanding that people process information in different and multiple ways which may interact with one another. Accordingly, teaching needs to devise sophisticated ways to facilitate the multiple processing systems of the brain, for instruction may often be better when multiple modes are used, not just the learner's dominant mode. Wittrock suggests that learning in schools be reconceived as a "generative-cognitive process"; that is, learning involves the active construction of meaning from stimuli, using verbal and imaginal

processing, or propositional (LH) and appositional (RH) processing. What's more, learning is basically a process of relating stimuli to previous experience, from which one induces and elaborates meanings and representations. And teaching is largely the process of organizing and relating new information to the learner's previous experience, thus stimulating the student to "actively" construct his/her own meanings and representations for what he/she is encountering in learning and from what reactions the teacher causes the student to generate. Moreover, in language learning and reading, the brain hemispheres interact with each other in recognizing shapes and phonemes, associating meaning with words and sentences by relating previous learning experiences to the new information in the text. Students need to associate sounds and meanings of words with recognizing their shapes. And inductive (synthesizing parts into wholes) and deductive reasoning (proceeding from rules to examples) facilitate lateral integration and thinking/learning. In addition, reading can be facilitated, for instance, by using pictures to improve the teaching and learning of syntax, vocabulary, and comprehension. What's more, verbal-semantic and imaginal processes can be integrated by having learners describe pictures with words and sentences, thus engaging both hemispheres. Finally, the findings of recent brain research on the lateralization processes of the cortex provide scientific evidence indicating that thinking, learning, and memory are "generative processes," often involving the "active construction" of representations and meanings in both hemispheres.

Wittrock, M.C. (1980). Learning and the brain. In M.C. Wittrock (Ed.), The Brain and Psychology. New York: Academic Press.

The author has done research in learning, particularly in the "generative processes" of learning and memory related to language acquisition and reading. Generative-cognitive processes are characterized as how learners generate meanings for written language by relating these new meanings to the students' knowledge and memories of previous experience; by this constructive process, learners make sense out of prose and connected discourse. In addition, cognitive functions cannot be reduced to neural structures

and psychological processes; the precise neurological mechanisms involved in different types of learning are not known. Moreover, self-generated verbal and imaginal representations of information facilitate learning and reading. The author especially draws on the RH for developing linguistic skills by using imagery to increase vocabulary skills.

Wittrock, M.C. (1981). Educational implications of recent brain research. Educational Leadership, 39(1), 6-9.

Individuals differ in their uses of the attentional and the organizational cognitive processes of the brain, involving individual cognitive styles, strategies, schemata, and related background information. What's more, students learn and remember what they actively construct mentally during teaching and studying; because the brain actively constructs meaning, students are responsible for constructing sentences, images, inferences, and metaphors in order to learn the information and to encode it into long-term memory, constituting a "generative process" of learning. And teachers facilitate this construction of meaning by guiding learners' attention, asking questions, providing images, propositions, metaphors, similes, and by stimulating motivation and arousal for generating mental elaborations and representations of the subject matter and concepts. However, repetition and reinforcement of the subject matter (reinforced practice drills) may lead to disinterest. The brain, on the other hand, responds best to novelty or unexpected events, and it seems that dendritic branches of neurons in the cortex increase in density in the brain's response to stimulating learning environments, although the findings from research are tentative. In addition, the paradigms for educational research should encompass the mental processes of learners and the individual differences in learning; accordingly, process-oriented models of learners' thought processes can lead to useful hypotheses and implications about about thinking, learning, and teaching. In sum, learning with understanding is a "generative process" of actively creating or constructing meaning of information processed in the brain.

Yellin, D. (1983). Left brain, right brain, super brain: The holistic model. Reading World, 23(1), 36-44.

In education, the once commonly accepted notion of a major or dominant hemisphere must give way to a more "whole-brain" orientation. Though hemispheric specialization may still be a relevant topic for discussion, the notion of teaching to the whole brain is now gaining more credence among educators in terms of a "holistic education." Holistic education can be characterized by Biofeedback, Yoga, and the Lozanov Method, which involves physical relaxation, mental concentration, and calming music (Baroque) during the lesson. All of these methods in a holistic education have a positive potential role in the classroom for helping students learn more efficiently, particularly successful in teaching reading as well as other subjects.